ORTHODONTICS:

Treatment need and treatment outcome

Essam A. Al Yami

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TREATMENT NEED AND TREATMENT OUTCOME

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The value of a smile:

"A smile costs nothing but gives much. It enriches those who receive without making poorer those who give. It brings rest to the weary, cheer to the discouraged, sunshine to the sad. Yet, it cannot be bought, begged, borrowed, or stolen, for it is no value until it is given away. Some people are too tired to give you a smile. Give them one of yours, as none needs a smile so much as he who has no more to give."
Frank Irving Fletcher

Dedicated to:
My mother
My wife
Our children

Contents

Chapter 1

General introduction

1.1 Introduction

It is estimated that at least one-third of the population has a clear need for orthodontic treatment. The prevalence of malocclusion varies among different countries and differs depending on the origin of the cited studies. For the Netherlands the orthodontic treatment need was found to be 39% for a population from 15 to 74 years of age using professionally defined criteria (Burgersdijk *et al.*, 1991). In the United Kingdom approximately one third of 11 to 12 years old children was in objective need of orthodontic treatment as determined by the Index of Orthodontic Treatment Need (Burden and Holmes, 1994). A comparable study in Hong Kong indicates that 41% of first year dental students was requiring orthodontic treatment (Tang, 1994). In Australia the percentage of the population that requires orthodontic treatment was estimated to be 36% using the DAI on 12 to 16 years old school children (Estioko *et al.*, 1994). In the Euro-Qual report (Ter Heege, 1997) an overview is given of studies in which professional need and demand has been determined within various populations. The professionally determined need varies from 20 to 77 per cent.

The presence of an obvious malocclusion is by no means the only factor that determines whether or not an individual will have orthodontic treatment. Shaw *et al.* (1991a) state that for the majority of prospective patients the eventual decision for treatment reflects a combination of features and aspirations of the clients (patient and/or parents) and the health care providers.

As with most medical interventions, however, orthodontic treatment is not without risks and limitations. The American Association of Orthodontists has produced an informed consent form that lists 15 major risks and limitations involved in orthodontic treatment (AAO, 1990). These risks may include: the possibility of tissue damage such as root resorption, loss of supporting bone, pulpal damage, irritation of soft tissues, enamel damage on debonding; increased susceptibility to dental disease f.e. decalcification and caries; post-adjustment tenderness, joint pain, headaches and ear problems during treatment; swallowing and aspiration of orthodontic appliances;

damage due to manipulation of dental instruments; blindness due to improper handling of the headgear; joint dysfunction following treatment; partial or total failure of treatment, and the lack of long-term stability of treatment results (AAO, 1990; Shaw *et al.*, 1991b; Richmond *et al.*, 1992a).

To be able to balance risks and benefits against each other it is important to have tools to categorize patients according to the urgency and need for treatment as well as treatment success. In such a way individuals with little treatment need can be safeguarded from the potential risks of orthodontic treatment (Shaw, 1988).

1.2 Indices

In recent years there has been increased interest in the development of methods that reduce subjectivity in the assessment of need as well as outcome of medical and dental treatment. In orthodontics this role may be fulfilled by the use of indices. Indices record traits of malocclusion in numerical or categorical format and have been developed to enlist a degree of objectivity into the assessment of malocclusion as opposed to subjective assessment.

Indices which determine treatment need can safeguard individuals with little need from the potential risks of treatment as described above. Similarly, these indices make it possible to give individuals with greatest treatment need priority when orthodontic and financial resources are limited, and when the availability of treatment is unevenly spread (Brook and Shaw, 1989; Moyers, 1990; Shaw *et al.*, 1991c; Richmond *et al.*, 1992a; Hill, 1992). Finally, a patient who expresses a firm treatment need, which is not objectively confirmed by examination, may accept the professionals advice against treatment more readily if the decision is based upon broadly agreed clinical agreement (index) rather than a personal view. The reverse is true when encouraging patients with fears about the discomfort or inconvenience of appliance therapy, saying their irregularity represents a widely agreed disadvantage for dental health (Holmes, 1992; Richmond *et al.*, 1992a; Shaw *et al.*, 1991c).

An index could be used also as a self-assessment instrument for the interested practitioner to test his own clinical performance and as a self teaching device to improve the quality of future treatment results (Perks, 1995). Also, it could serve as an indicator for quality control within health care programmes (Shaw *et al.*, 1991c; Hill, 1992; Richmond *et al.*, 1992a). Indices of treatment outcome provide one standard of practice regardless of the qualification or experience of the clinician. It encourages all practitioners to update their knowledge and skill. This eventually will protect patients and will improve the quality of orthodontic treatment care (Moyers, 1990).

The use of reliable and valid occlusal indices in orthodontics provides also the opportunity to reduce subjective bias and to standardise the criteria through which judgements are made throughout the profession. With this uniformity meaningful comparisons between various surveys and patient populations become possible (Richmond *et al.*, 1992c).

According to Shaw *et al.* (1991c) and Ter Heege (1997) an ideal index should be 1) reliable in use, 2) clinically valid, 3) sensitive to the needs of the patient, 4) acceptable to both the public and the profession, 5) administratively simple to operate, 6) sensitive through out the scale, 7) amenable to statistical analysis, 8) an examination which should require a minimum of judgement, 9) able to reflect need in a population matching the expertise and resources available.

In the past many quantitative indices to record malocclusion have been developed. It is important to distinguish indices that classify malocclusions into types or record prevalence in epidemiological studies, from those indices that attempt to record treatment need or priority. Furthermore, there are indices used to record treatment success and treatment difficulty. In this chapter we limit ourselves to those indices that record treatment need and those that measure treatment outcome. Both types of indices can be based on dental variables or can include aesthetic variables as well.

1.3 Indices for treatment need

Many indices have been developed to record treatment need. The aims of treatment priority indices are to record treatment need in a population, to assign priority to cases and to plan resources (Ter Heege, 1997). Examples of such indices are: the Malocclusion index (Massler and Frankel, 1951); the Occlusal Feature Index, OFI (Poulton and Aaronson, 1961); the Malocclusion severity index (Hill, 1992); the Handicapping Labio-lingual Deviation (Draker, 1960); the Treatment Priority Index, TPI (Grainger, 1967); the Handicapping Malocclusion Assessment Record, HMAR (Salzmann, 1968); and the Swedish National Board for Health and Welfare Index (Linder-Aronson, 1974). Lundström (1977) proposed an index based on eleven indication factors.

Several studies have been performed to compare different indices regarding their validity, but no definitive conclusions can be drawn from these studies (Banack *et al.*, 1972; Albino *et al.*, 1978; Jarvinen and Väätäjä, 1987; So and Tang, 1993). Although some indices record the treatment need including aesthetic variables, many authors concluded that these indices failed because they only physically measure occlusal traits on dental casts, without taking into account subjective symptoms and social sufficiency (Carlos, 1970; Grewe and Hagan, 1972; Katz, 1978; Jenny *et al.*, 1980; Hill, 1992; Jenny and Cons, 1996a). Prahl-Andersen affirmed in 1979 that criteria to assess orthodontic treatment need have to include three factors: objective signs, subjective symptoms and social sufficiency. This means objective assessment of dental status, indication of the patient's recognition of need for treatment and recognition by society (Cons *et al.*, 1989).

The first popular index which attempted to measure dental aesthetics objectively was the Eastman Esthetic Index, EEI (Howitt *et al.*, 1967). The Social Acceptability Scale of Occlusal Conditions, SASOC was developed as a method for determining the social acceptability of dental appearance (Jenny *et al.*, 1980). The Dento-Facial Attractiveness scale, DFA, was developed to provide an objective assessment of relative dento-facial attractiveness which is independent of an evaluation of functional impairment (Tedesco *et al.*, 1983).

Another standardized rating scale of dental attractiveness is the Standardized Continuum of Aesthetic Need, SCAN (Evans and Shaw, 1987). Peerlings *et al.* (1995) described the development of the Facial Attractiveness Scale. Facial aesthetics was determined at two different ages (11 to 13 years and 14 to 16 years) on a three-quarter facial photograph of a smiling face. Two indices contained aesthetic as well as clinical criteria. Firstly, the Index of Orthodontic Treatment Need (IOTN), which contains two separate components to record the aesthetic impairment caused by the malocclusion and the dental health and functional indications for treatment (Brook and Shaw, 1989). Secondly, the Dental Aesthetic Index (DAI) which links the people's perceptions of aesthetics with anatomic trait measurements by regression analysis to produce a single score obviating the need (Cons *et al.*, 1986; Jenny and Cons, 1996b). It may appear that both indices are very similar at first glance, but closer comparison of the two shows that in their method of development, their sensitivity, their reliability, their validity, and in their ability to rank order priorities for orthodontic treatment the two indices are actually dissimilar (Jenny and Cons, 1996a).

Dental conditions in the anterior region such as tooth displacements, missing teeth and overjet and overbite are related to facial aesthetics because of visibility (Sergl and Stodt, 1970; Shaw, 1981; Tedesco *et al.*, 1983). But it seems to be that there is a difference between dental aesthetics with retracted lips as it is estimated in these indices and dental aesthetics as part of the entire facial complex.

1.4 Indices for treatment result

Only few indices were devised to assess treatment success. The Occlusal Index (Summers, 1971) which was initially designed for other tasks, has been used to evaluate the success of treatment (Pickering and Vig, 1975; Elderton and Clark, 1983; Shaw *et al.*, 1991c). Eismann (1974) proposed a method of evaluating the efficiency of orthodontic treatment by determining and measuring fifteen essential factors according to clearly defined rules on the

initial, final and control casts. Other methods are "Six Keys to Optimal Occlusion", where six characteristics of normal occlusion shared by non-orthodontic normals are used i.e. molar relationship, crown angulation and inclination, rotations, spaces and occlusal plane (Andrews, 1972); the Ideal Tooth Relationship Index, ITRI, which is a static occlusal analysis that is based on ideal interarch and intra-arch relationships consisting of specific cusp to marginal and triangular ridge contacts, interincisal contacts, and interproximal contacts (Haeger *et al.*, 1992); and the Peer Assessment Rating Index, PAR index (Richmond *et al.*, 1992a; 1992b) which will be described thoroughly later on.

It would seem appropriate to measure treatment outcome by the same tool that measures treatment need. An unsuccessful attempt to evaluate orthodontic treatment outcome by using the DAI was described by Lobb *et al.* (1994). Richmond *et al.* (1994) tried to assess the success of orthodontic treatment, relative to aesthetic and dental need by using the IOTN index, but it appeared to be that a precise conclusion about treatment outcome could not be obtained.

1.5 Index of Orthodontic Treatment Need IOTN

1.5.1 Description

The Index Of Orthodontic Treatment Need or IOTN has been designed to assess treatment need. The IOTN was described by Brook and Shaw (1989), and modified by Richmond *et al.* (1992a). It is based on the index of the Swedish Medical Health Board (Linder-Aronson, 1974). The Index of Orthodontic Treatment Need (IOTN) attempts to rank malocclusion in terms of the significance of various occlusal traits for an individual's dental health and perceived aesthetic impairment. It intends to identify those individuals who would most likely benefit from orthodontic treatment. The index incorporates a dental health component and an aesthetic component (Brook and Shaw, 1989; Shaw *et al.*, 1995).

The Dental Health Component (DHC) comprises a synthesis of the

current evidence for the deleterious effects of malocclusion. It records the various occlusal traits of a malocclusion that would increase the morbidity of the dentition and surrounding structures. There are five grades ranging from grade 1 "No need for treatment" to grade 5 "Very great need". Dento-facial deformities such as cleft palate, and severe overjet greater than 9 mm would fall into grade 5. Displacements between contact points less than 1 mm would fall into grade 1. Importantly, only the worst occlusal feature is recorded.

A ruler has been designed containing all the information in abbreviated form, necessary to record the DHC (Fig. 1-1). The ruler has been developed for the clinical setting in which information is collected regarding competence of the lips, mandibular displacement on closure and masticatory / speech problems.

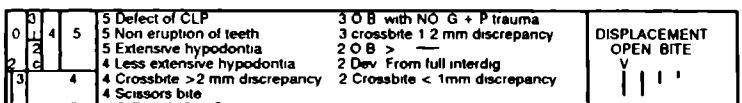

Figure 1-1: *The IOTN ruler (Richmond et al., 1992a).*

Other utensils for application of the IOTN are: a pretreatment dental cast, a pair of straight compasses and the scale with 10 intra-oral pictures to determine the AC (Fig. 1-2).

There are two ways of recording the DHC. The first is to record the grade only. In the second way, the initiating feature would be recorded, for example, an overjet greater than 9 mm would be 5a (the grade being 5 and the overjet signified by the letter). The second method provides more information regarding the prevalence of the specific occlusal traits. The DHC is usually recorded at chair side by direct examination of the subject but can also be recorded from dental casts. When using dental casts alone it is unlikely that clinical information will be readily available to the examiner. For this reason a protocol has been developed which should be employed when using dental casts.

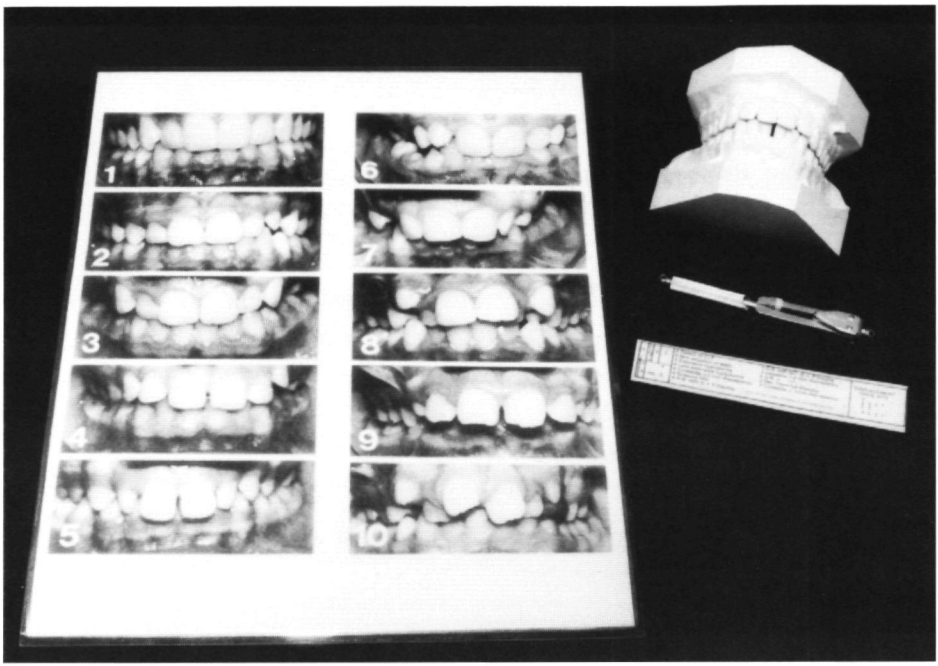

Figure 1-2: *Utensils for application of the IOTN: pretreatment dental cast, Dental Aesthetic scale, a pair of straight compasses and the IOTN ruler.*

The Aesthetic Component consists of a scale of ten colour photographs showing different levels of dental attractiveness (Evans and Shaw, 1987). Photographs have been used as a valid, reproducible and representative way for detecting dento-facial aesthetics (Howells and Shaw, 1985; Peerlings *et al.*, 1995). The dental attractiveness of prospective patients can be rated with reference to this scale. Grade 1 represents the most and grade 10 the least attractive arrangement of the front teeth. The score reflects the aesthetic impairment. Black and white photographs are used for dental cast assessment. These have the advantage that raters are not influenced by oral hygiene, gingival conditions or poor colour matches in restorations affecting anterior teeth (Woolass and Shaw, 1987). A comparison of ranking dental aesthetics by two numerical scales illustrated with three or two photographs and the

aesthetic component of the IOTN indicates that reducing the number of photographs in the aesthetic scale did not significantly improve the dentists ability to rank dental aesthetics (Burden, 1995a).

The Index of Orthodontic Treatment Need has been validated by 74 dentists and the grades have been grouped to reflect British dental opinion (Richmond *et al.*, 1992b; 1992c). The Dental Health Component can be categorised into three groups: 1 and 2: no need for treatment; 3: moderate / borderline need for treatment; 4 and 5: need for treatment (Richmond *et al.*, 1992a). The Aesthetic Component grading can be split into three main groups: grades 1-4: no need for treatment; grades 5-7: moderate / borderline need for treatment; grades 8-10: need for orthodontic treatment.

1.5.2 Results of studies with the IOTN

Three types of studies can be distinguished in the literature about the IOTN: studies concerning the index itself, studies comparing the IOTN with other indices, and studies providing results concerning treatment need.

Buchanan *et al.* (1994) studied the reliability of the IOTN applied directly to the patient or on dental casts. The IOTN was applied clinically to a group of patients and later on to dental casts and photographs of the same patients. Examiner reliability and agreement between the information obtained clinically and from dental casts was high. There was, however, poor agreement for the Aesthetic component scored from photographs, when compared with scores recorded clinically or from dental casts. Another study by Lunn *et al.* (1993) was performed to assess the use of the IOTN in dental public health. Dentists in the community dental service were taught how to use the index through a hierarchical training and calibration programme. These dentists then tested the index in their practice and reported back their findings. The results indicate that the IOTN has potential in dental public health but some modifications were suggested. Dentists can easily be trained to record the aesthetic and dental health components of the IOTN to a satisfactory level (Richmond *et al.*, 1995; Burden *et al.*, 1995b). A recent questionnaire survey by Holmes and Willmot (1996) indicated that 74.6% of the respondents were routinely recording the Dental Health Component of the

IOTN for their new patient referrals.

The Occlusal Index (OI) and the IOTN were used in a study by So and Tang (1993) and Tang and So (1995) for assessing orthodontic treatment need and demand. They concluded that both indices had short out-comings. The Occlusal Index, however, was much more time-consuming to use than the Index of Orthodontic Treatment Need. The OI assessment correlated better with the individuals own perception of appearance than did the IOTN, and the treatment need indicated by the OI also correlated better with the individuals actual treatment demands. While neither the OI nor the IOTN is ideal, the simplicity of the IOTN gives it an advantage over the OI because it enables one to study a large population group without spending a tremendous amount of time. Another comparison of three indices of orthodontic treatment need, DAI, IOTN and Handicapping Labio-lingual Deviation with a California Modification (HLDCal Mod) was made with the consensus opinion of a panel of 15 experienced orthodontists. The results indicated the optimum scores for these indices being 28 for the DIA, 12 for the HLDCal Mod, and 3 for the IOTN. These scores are the point at or above which treatment is indicated. These scores differed from the scores currently in use for these indices being 31 for the DIA, 26 for the HLDCal Mod, and 4 for the IOTN (Beglin *et al.*, 1997).

The prevalence of orthodontic treatment need amongst 955 12-year-old Sheffield (UK) children, at various levels of dental health and aesthetic need, has been assessed using the Index of Orthodontic Treatment Need. Only 5.3 per cent of children, scoring 1 on both the dental health and aesthetic components of the Index, had absolutely no treatment need. A farther 25.5 per cent, scoring 3 or less on the aesthetic scale and 2 or less on the dental health scale had little need for treatment (Holmes, 1992). O'Brien *et al.* (1993) found great variation between departments in the pretreatment IOTN grade allocation for both the AC and DHC. The highest proportion of the pretreatment cases with a "Need" for treatment based on dental health criteria was 98% and the lowest was 70.6%. A similar pattern was evident when variation in the AC was examined. The highest proportion of pretreatment patients in "Great Need" for treatment was 78.3% and the lowest was 49%.

The IOTN was applied to the pre- and post-treatment dental casts of 220 patients from Norwegian orthodontists. On average, the AC scores started at 7 and finished at 2. The DHC commenced in the "Need for treatment" category and finished in the "No need" category (Richmond and Andrews, 1993). Richmond *et al.* (1994) assessed the need for orthodontic treatment before and after treatment in 1225 cases. On the whole, full upper and lower fixed appliances brought about a greater improvement in the Aesthetic and Dental Health Components compared to other appliance techniques, and were less likely to make the occlusion worse. It was found that certain occlusal traits were more likely to be successfully treated than others. A common problem resulting from treatment was the development of cross-bites.

1.6 Peer Assessment Rating PAR

1.6.1 Description

The PAR index was developed to record malocclusion in the mixed and permanent dentition. The index was formulated over a series of six meetings in 1987 with a group of 10 experienced orthodontists (British Orthodontic Standards Working Party). Dental casts of various treated and untreated occlusions were examined and discussed until agreement was reached in order to obtain an estimate of alignment and occlusion. A scoring system was developed and a ruler (Fig. 1-3) designed to allow analysis of a set of dental casts (Shaw *et al.*, 1991c). Utensils required for application of the PAR are: the PAR ruler, pre- and post-treatment dental casts, and a pair of straight compasses (Fig. 1-4).

The individual scores for the various components of alignment and occlusion are finally summed to obtain a total score that represents the degree a case deviates from normal alignment and occlusion. A score of zero indicates good alignment and higher scores (rarely beyond fifty) indicate increased levels of irregularity. The index is applied to both start and end of treatment dental casts, and the change in the total score reflects the degree of improvement and the success of orthodontic intervention.

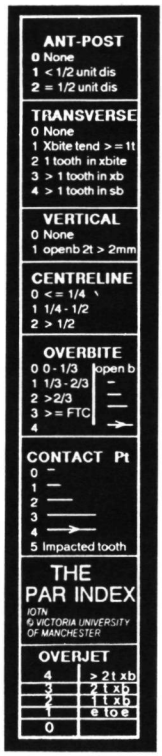

Figure 1-3: *The PAR ruler (Richmond et al., 1992a).*

The components of the PAR index have been weighted statistically to reflect consensus opinion of 74 examiners, by multiplying some of the sub-components to certain power to reflect current British orthodontic opinion. The index is flexible in that way that the weighting can be changed to reflect future standards currently being achieved in other countries. Some of the components did not appear to have a predictive power and consequently were excluded from the weighted PAR-Index. (Richmond *et al.*, 1992b; 1992c). The PAR index has also been validated by using the opinion of an American panel of eleven orthodontists. The findings resulted in weighting factors that were different from the British validation (DeGuzman *et al.*, 1995).

There are basically three methods of assessing improvement using the

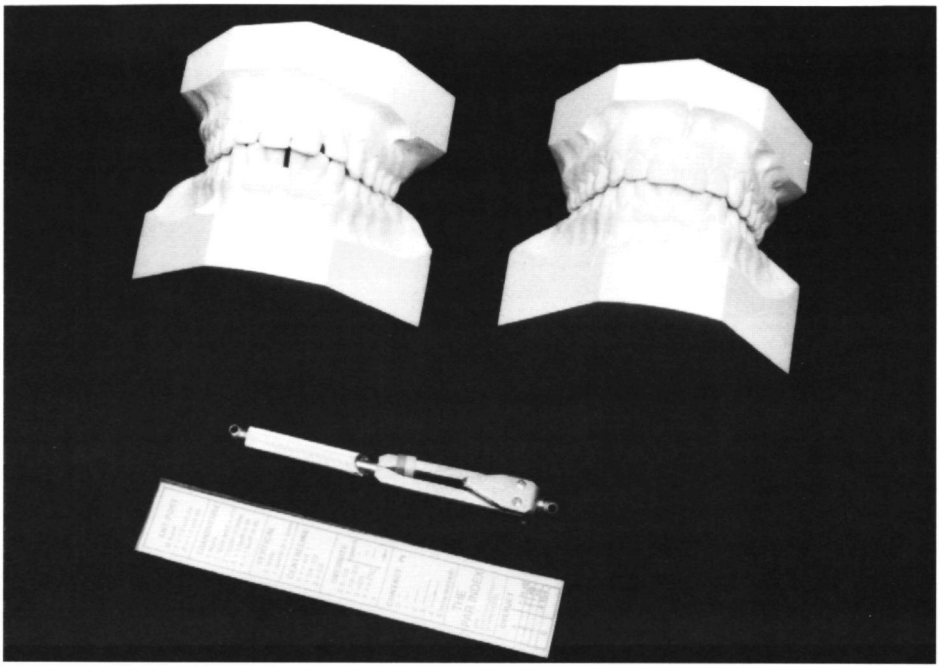

Figure 1-4: *Utensils for application of the PAR: pre- and post-treatment dental casts, a pair of straight compasses and the PAR ruler.*

PAR-Index: a. absolute reduction in the weighted PAR score, b. using the nomogram, c. percentual reduction in the weighted PAR score. The percentage reduction in the weighted PAR score (Fig. 1-5) gives a more sensitive assessment than the absolute change or when using the nomogram alone (Fig. 1-6). In the nomogram the pretreatment weighted PAR score is given on the horizontal axis and the post-treatment weighted PAR score on the vertical axis. The pre- and the post-treatment scores are read off their respective axis. Where the intercept falls indicates the degree of improvement which only provides three broad bands of treatment change: worse-no different, improved and greatly improved (Richmond *et al.*, 1992a; 1992b; Shaw *et al.*, 1991c). A high standard of treatment is achieved when the proportion of cases falling into the "worse or no different" category of an

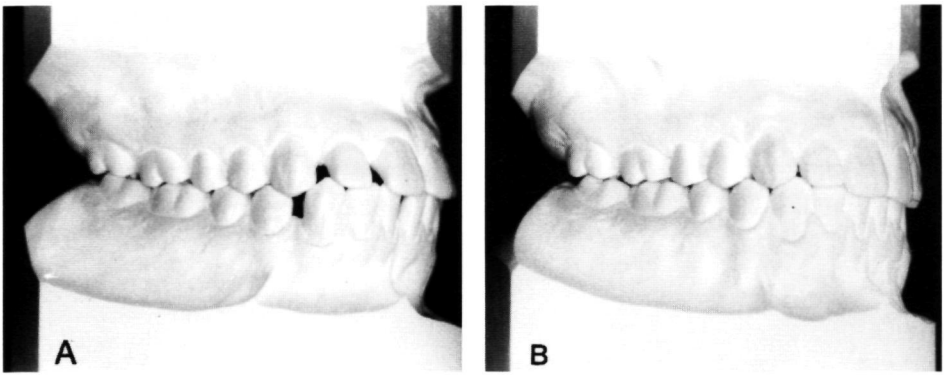

Figure 1-5: *a. pretreatment dental cast, PAR score: 12; b. post-treatment dental cast, PAR score: 1. The absolute reduction in the PAR is 11, and the percentual reduction is 91.7%.*

individuals case load is negligible and the mean percentage reduction in weighted PAR score is high e.g. greater than 70 percent (O'Brien *et al.*, 1993; Richmond *et al.*, 1992b; 1992c).

The experience of the PAR-Index is still at an early stage, although several practical uses are described. That the PAR-Index has an excellent validity, has been demonstrated in a study of Shaw *et al.*, (1991c). The reliability and consequently the reproducibility, within and between several examiners was also tested in a series of investigations. Intra-examiner reliability achieved a high level in the different studies. Inter-examiner reliability was also excellent (Shaw *et al.*, 1991c; Richmond *et al.*, 1992c; Buchanan *et al.*, 1993; O'Brien *et al.*, 1993). The weighted PAR-Index showed a slight improvement in the reliability over the unweighed version (unweighed R = 0.91; weighted R = 0.93) (Richmond *et al.*, 1992b). The PAR-Index offers uniformity, objectivity and standardisation in assessing the outcome of orthodontic treatment. The index is amenable to statistical analysis and quick to apply. Finally, Richmond *et al.* (1993) showed that it is possible to teach staff without dental qualification or training to use the weighted PAR Index to a high level of reliability.

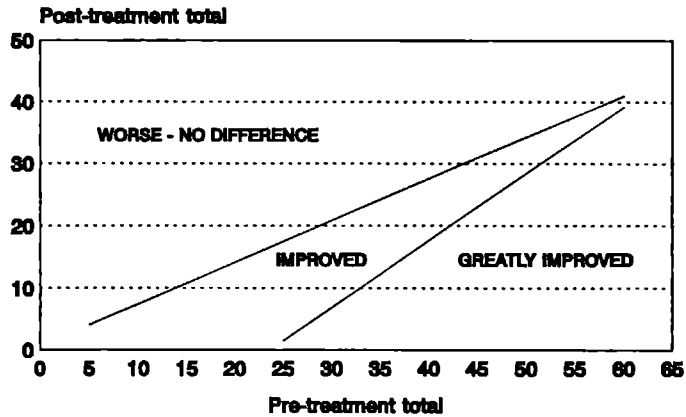

Figure 1-6: *The nomogram illustrates the three broad bands of treatment change. The intercept of pre- and post-treatment scores indicates the degree of improvement (Richmond et al., 1992a).*

1.6.2 Results of studies with the PAR

O'Brien *et al.* (1993) showed, using the PAR-Index, a variation in treatment outcome between operator groups with different experience. Patients treated by consultants and senior registrars had a mean change in the weighted PAR of 70.8%. The more junior staff reached a mean change of 63.8%. O'Brien *et al.* (1993) collected a total of 1630 cases from 17 hospital-based orthodontic departments and analyzed them for standard of treatment with the PAR-Index. The overall chance of a beneficial outcome was of a high standard, the mean percentage change over all departments was 67.6%. In this investigation only 8 per cent of the patients were allocated to "the worse or no different" group. A higher overall chance of a beneficial outcome in the hospital orthodontic service than in the general dental service was also the conclusion of another pilot study by Richmond *et al.*, (1992d). The majority of cases were reaching a substantial improvement after treatment. In this pilot study only 4 per cent of the 100 patients were allocated to the "worse or no different" group (Shaw *et al.*, 1991c). In a sample of 220 cases collected from Norwegian specialist orthodontists, the standard of treatment was also

better. The mean percentage reduction of the weighted PAR score was 78 per cent and only 4 per cent of the cases were categorized as "worse or no different" (Richmond *et al.*, 1992c).

The choice of treatment methods is the most important variable in the outcome of treatment standard. Fixed appliances in two arches always were more effective than single arch fixed appliances. The mean percentual reduction in the PAR score was 71.4%, 54.6% and 49.8% for cases treated with two arch fixed appliances, single arch fixed appliance and cases treated only with a removable appliance respectively (Richmond *et al.*, 1992c). In a comparable study the reduction was 75.5% for cases treated with two arch fixed appliances, 59.4% for cases treated with single arch fixed appliance and 51.8% for cases treated only with a removable appliance (O'Brien *et al.*, 1993).

O'Brien *et al.* (1993) showed that the treatment outcome is also region (department)-bound and varied between 50.9% to 77.9%. In an investigation of the General Dental Service in England and Wales, the orthodontic treatment standards appeared to be poor (Richmond *et al.*, 1992d). In this sample of 1010 cases treated with removable and/or fixed appliances, one out of every five patients had an occlusion which was unimproved or made worse as a result of treatment. The overall mean percentage reduction in weighted PAR score was 55 per cent. In another similar study, 1200 pairs of dental casts were assessed with both the PAR-Index and the IOTN. It was seen that the risk of getting an "unimproved or made worse" treatment was especially high for cases of borderline need (Shaw *et al.*, 1991c).

The effectiveness of Class II division 1 treatment was evaluated by O'Brien *et al.* (1995). They concluded that the only variable that influenced the percentage change in the PAR score was the pretreatment PAR score. The higher the initial PAR score, the greater was the improvement in the occlusion that resulted. Long term evaluation of treated Class II, division 1 malocclusions utilizing the PAR index revealed that maintenance of post-treatment results was only achieved in 60% one year postretention and in 38% at ten years postretention. The major factor involved in this deterioration appeared to be late lower anterior crowding (Otuyemi and

Jones, 1995).

The PAR index was used to evaluate the quality of orthodontic treatment at several orthodontic institutes. Tolidis and Sandy (1994) suggested that the treatment provided by undergraduates in Bristol Dental School (UK) in the years 1982-1987 was of significantly higher standard as measured by the PAR index than that achieved in more recent years. Feghali *et al.*, (1995) assessed a sample of 100 most recent consecutively debonded orthodontic cases at the Case Western Reserve University CWRU (Ohio, USA) using the PAR index. The averages for pre- and post-treatment PAR scores were 34 $\pm$ 10 and 11 $\pm$ 5.6 respectively. Another study showed that the quality of orthodontic treatment delivered at CWRU has remained stable comparing cases debonded between 1993 and 1994 to those debonded between 1980 and 1985 (Feghali *et al.*, 1996, Hassanein *et al.*, 1996). A comparative study was done between the graduate orthodontic clinics in Pittsburgh and Columbus (USA), comparing the efficiency before and after the year 1994. The results indicated that the efficiency in both programs increased as measured by the decreased treatment duration between the pre and post 1984 epoch (Rinaldi *et al.*, 1996). Another comparative study was done between Case Western Reserve University CWRU and the University of Southern California USC. The outcome of orthodontic treatment at both institutes was completed with a similar overall success rate of 97%, despite of geographic and demographic differences (Feghali *et al.*, 1997). An evaluation of orthodontic treatment outcome in private orthodontic practices over a ten years interval was conducted. The effectiveness of treatment remained constant while the time and number of visits for treatment decreased between 1980 and 1990. This study demonstrates the feasibility of conducting such studies in a private practice setting (Zody *et al.*, 1997).

The outcome of orthodontic treatment, however, is not purely the result of orthodontic mechanical intervention alone. Normal biological changes may influence the orthodontic treatment outcome either in a positive or in a negative manner. The influence of physiological growth on the PAR index was tested on longitudinal untreated subjects enrolled in the Bolton Brush Growth Study. The results showed that normal growth has a chance of 16%

to 22% of achieving at least a 30% reduction in the PAR score depending on the length of the interval between the first and the second observation (Afsharpanah *et al.*, 1995, 1996).

Short term studies may provide the "golden standard" as was proposed by Tahir *et al.* (1997), being representative for "the best the profession has to offer" against which other samples could be compared. Other short term studies reported an immediate outcome of treatment (Fox, 1993; Kerr *et al.*, 1993, O'Brien *et al.*, 1993). On the other hand long term evaluation of large samples provides more insight into the level of final treatment outcome that can be obtained which can attribute to the development of standards for quality control in orthodontics (Fox and Chadwick, 1994; Otuyemi and Jones, 1995).

Kahl-Nieke *et al.* (1996) emphasised that 'the review of the literature points out the need for a quantitative and qualitative assessment of post-treatment changes by using a sample that is large enough for statistical analysis consisting of cases out of retention for at least 10 years'.

1.7 Aims of this study

The aims of this thesis were to assess the correlation between the Facial Attractiveness Scale and the Aesthetic Component of the IOTN index, to assess the biological changes in a non-orthodontic sample between 12 and 22 years of age using the PAR index, and to perform a short-term and long-term analysis in a large sample of treated patients of both the treatment need, as measured with the IOTN and the treatment outcome, as measured with the PAR index.

1.8 Overview of the thesis

- In Chapter 2 it was investigated whether dental aesthetics as measured by the Aesthetic Component of the IOTN correlates with facial aesthetics

as measured by the facial attractiveness scale.

- In Chapter 3 biological changes were assessed in a non-orthodontic sample between 12 and 22 years of age using the PAR index.
- In Chapter 4 treatment need before treatment and five years postretention were evaluated.
- In Chapter 5 the overall quality of orthodontic treatment and treatment duration was assessed over a long time span in a large university clinic sample.
- In Chapter 6 the long-term post-treatment results were studied until 20 years postretention utilising the PAR index.
- In Chapter 7 treatment outcome was compared for Angle Class I, II/1, II/2, and Class III malocclusions until five years postretention as measured by the PAR index.

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Chapter 2

Assessment of dental and facial aesthetics in adolescents

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2.1 Abstract

The Index of Orthodontic Treatment Need (IOTN) is currently widely used for clinical as well as epidemiological purposes. The aesthetic component of this index focuses on dental aesthetics and does not include facial aesthetics. The aim of the present study was to evaluate whether dental aesthetics as measured by the Aesthetic Component (AC) of the IOTN correlates with facial aesthetics.

Facial attractiveness of 69 males and 75 females was scored on facial photographs at two different ages (11 to 13 years and 14 to 16 years). Scoring of the AC of the IOTN was undertaken on the dental casts. Increments between the observations at the two ages were calculated. To assess the association between scores of dental and facial aesthetics, correlation coefficients were calculated.

There was a highly significant influence of orthodontic treatment on facial and dental aesthetic scores in the group which was not treated orthodontically at the first observation and was treated orthodontically at the second observation. No correlation, however, was found between the increments in the facial aesthetic score and the increments in dental aesthetic score. The results indicate that facial aesthetics and dental aesthetics are influenced by different factors. Therefore both dental and facial aesthetics should be evaluated separately when judging dento-facial aesthetics.

2.2 Introduction

Many procedures performed by orthodontists or prescribed for their orthodontic patients such as functional appliance therapy, extractions, and orthognathic surgery, can alter facial appearance (Crawford, 1991; Lew, 1992; Bravo, 1994; Levin, 1994; Pancherz and Anahus-Pancherz, 1994). Current orthodontic treatment philosophies strive for occlusal goals that match with facial aesthetics (Mackley, 1993; Sarver, 1993). The measurement of facial aesthetics, however, seems to be a subjective measurement that depends on many variables. Within each race and sex there appears to be a balance of facial features that are viewed by the majority as being "pleasing to the eye" (Bravo, 1994). Psychologists state that our perception of form depends on the development of "form concepts". The more frequently we observe a particular facial pattern, the more likely we perceive it as "correct". People seem to share a common basis for aesthetic judgement regardless of nationality, age, sex, or occupation (De Smit and Dermaut, 1984; Cons and Jenny, 1994). Television, movies, newspapers and magazines all provide daily reinforcement for facial stereotypes (Ford *et al.*, 1966; Child and Iwao, 1968).

Most investigations with respect to orthodontics and dento-facial aesthetics have been limited mainly to the establishment of a hierarchy of treatment need, or to the preference of dento-facial appearance (Peerlings *et al.*, 1995). Nowadays, the IOTN introduced by Brook and Shaw (1989), later modified by Richmond *et al.* (1992), is widely used to establish treatment need. The index has two components: a Dental Health Component (DHC) and an Aesthetic Component (AC). The index attempts to rank malocclusion in terms of the significance of various occlusal traits for an individual's dental health and perceived aesthetic impairment. The AC of the IOTN consists of ten intra-oral pictures on a photographic scale for recording the aesthetic impairment related of the malocclusion (Evans and Shaw, 1987). With this scale it is possible to score the aesthetic component from photographs, from dental casts, or clinically. One of the shortcomings of this index, however, is that it measures only dental aesthetics. Katz (1978) and

Tedesco *et al.* (1983) have stated that more attention should be given to methods that provide a natural reproduction of the face and anterior teeth alignment when determining dento-facial aesthetics.

The facial aesthetic scale of Peerlings *et al.* (1995) appears to meet these criteria. This scale was developed to measure facial aesthetics on facial photographs showing a three-quarter view of a smiling face and the anterior teeth. The facial aesthetic scale consists of four components, each having been developed for specific age and sex groups (male and female 11-13 years; male and female 14-16 years). The categorization of the facial aesthetics according to age and sex was supported by knowledge gained from growth studies which have clearly shown that dynamic, sex-dependent changes in dental, skeletal, and facial integument occur over the entire period of active growth and, therefore, aesthetic standards must be different for different age groups (Nanda and Ghosh, 1995).

From the above mentioned studies it can be concluded that dental aesthetics is not the only parameter that should be measured when assessing treatment need or treatment outcome. However, if measurements of dental and facial aesthetics show a high correlation, then only one scale could be used to assess treatment need or treatment outcome. The aim of the present study was to evaluate whether dental aesthetics as measured by the AC of the IOTN, correlates with facial aesthetics.

2.3 Subjects and methods

From the files of the Department of Orthodontics and Oral Biology, University of Nijmegen (The Netherlands), children of two different age groups were chosen. Only Caucasian children were included without facial or dental trauma or congenital defects. Angle Class III malocclusions were excluded because of the small number. Two groups of children were used in this study, prior to and on completion of orthodontic treatment. Children in group A1 (male n = 35; female n = 37) were 11 to 13 years of age and were in the pretreatment phase. Children in group B1 (male n = 34; female

n = 38) were also 11 to 13 years old, but were in the post-treatment phase. These children were followed until the age of 14 to 16 years. At that age, A1 was in the post-treatment phase (A2) and group B1 was several years in the postretention phase (B2). As there were some missing dental casts, the number of valid observations at the post-treatment phase (A2) was smaller (male n = 33; female n = 36).

At both ages, the following records were used for evaluation: facial photographs with a standard three-quarter view of the smiling face and dental casts. The photographs were taken with a macro lens Olympus OM-4 Ti. camera system and Olympus Zuiko Auto-Macro lens 135 mm (Olympus Optical Co. Ltd, Tokyo, Japan). An Ekta-chrome professional daylight (EPD) colour film (Kodak, Kodak BV, Odijk, The Netherlands) was used. The size of the facial photographs was 10 x 15 cm. The dental casts were standard orthodontic study models, taken at both ages.

Facial aesthetics (FA) was determined at two different ages (11 to 13 years and 14 to 16 years) on the facial photographs, using the facial aesthetic scale developed by Peerlings *et al.* (1995). The FA is scored by comparing the picture with a standardized scale resulting in a score from 25 to 175 (25 = worst; 175 = best). For this study the data from one of Peerlings' samples (1992) was used. Scoring of dental aesthetics (range 1 to 10) was done by using the AC of the IOTN. The AC is scored by comparing the dental cast with a standardized series of 10 photographs resulting in a score from 1 to 10 (1 = best; 10 = worst). As recommended (Woolass and Shaw, 1987; Buchanan *et al.*, 1994), the black and white photographic scale was used to assess the AC on the dental casts to exclude variables such as cleanliness, tooth colour and gingival health.

Three examiners were incorporated in this study. To determine the measurement error in the recording of the AC and to assess the intra- and inter-observer agreement, a random sample of dental casts of 18 patients was evaluated by the three observers. For each patient two different dental casts (pretreatment and post-treatment) were measured twice. The time interval between the two measurements was at least three months.

2.4 Statistics

The magnitude of the duplicate error was calculated for the AC score of the pretreatment and post-treatment dental casts separately. Systematical differences between observers were tested by the paired t-test. The inter- and intra-observer reliability was estimated by means of Pearson's correlation coefficients between duplicate measurements.

Pearson's correlation coefficients were calculated to assess the correlation between the scores for dental and facial aesthetics. Increments were calculated between the first and the second observations of group A and group B respectively. The significance of change over time was tested with the paired t-test. Finally, the correlation of the increments between facial aesthetics (FA) and dental aesthetics (DA) was determined with Pearson's correlation coefficient.

2.5 Results

2.5.1 Reproducibility of measurements

No significant systematical differences were found between examiners (paired t-test). The measurement errors were 0.34 and 0.55 scale point (scale from 1 to 10) for the intra- and the inter-observer measurement respectively, indicating a high level of reproducibility. The intra-observer correlation ranged from 0.96 to 0.97 and the inter-observer correlation from 0.89 to 0.96. This also showed a high level of reliability.

2.5.2 Variables

Mean and standard deviation for facial and dental aesthetics are given in Table 2-1. A higher facial aesthetic score means a more attractive facial appearance, while a higher dental aesthetic score means a lower dental attractiveness. After grouping the sample according to gender and treatment phase, i.e. pretreatment (A1), post-treatment (A2 and B1), and post-retention (B2), it was found (Table 2-2) that in the pretreatment phase the FA for

Table 2-1: *Mean, standard deviations and number of valid observations of facial aesthetics (FA) and dental aesthetics (DA) for each gender and group.*

groups		Facial aesthetics		Dental aesthetics	
		male	female	male	female
pretreatment	n	35	37	35	37
(A1)	mean	84.5	87.9	7.8	7.5
(11 to 13 years)	sd	18.8	17.3	1.9	1.8
post-treatment	n	35	37	33	36
(A2)	mean	102.1	93.1	2.4	2.3
(14 to 16 years)	sd	14.5	23.7	0.9	0.7
post-treatment	n	34	38	34	38
(B1)	mean	93.0	103.8	3.2	2.8
(11 to 13 years)	sd	18.2	18.4	1.7	1.4
postretention	n	34	38	34	38
(B2)	mean	104.5	97.2	3.5	2.4
(14 to 16 years)	sd	15.9	28.4	1.9	1.0

males showed a highly significant correlation with DA ($r = -.48$; $p < 0.01$). However, in the post-treatment group of the same age (B1) such a correlation was found only among the females. For the 14 to 16 years old children of both sexes in the post-retention phase (B2), significant correlations were found between FA and DA. To test the influence of treatment on dental and facial aesthetics, the increments were tested between A1 and A2 and between B1 and B2 (Table 2-3). Group A, which was treated between A1 and A2, showed a significant increase in FA, meaning a positive effect on facial aesthetics. The DA decreased significantly, meaning a positive effect on dental aesthetics. In group B, which was an observation between B1 (post-treatment) and B2 (several years after retention), no significant changes were found for FA and DA. No significant correlations existed between the increments of FA and the increments of DA.

Table 2-2: *Correlation coefficients between facial aesthetics (FA) and dental aesthetics (DA) according to gender and group.*

	FA							
	pretreatment (A1) (11-13 yrs)		post-treatment (A2) (14-16 yrs)		post-treatment (B1) (11-13 yrs)		postretention (B2) (14-16 yrs)	
	male	female	male	female	male	female	male	female
DA	-.48**	-.18	-.16	-.14	-.20	-.32*	-.47**	-.32*

** = $P < 0.01$
* = $P < 0.05$

2.6 Discussion

In this study, two groups of patients were evaluated. The children of group A were 11 to 13 years of age at the start of the study and they had not yet been treated. The children in group B were also 11 to 13 years of age at the start of the study, but their treatment had already finished. Dental and facial aesthetics of both groups were assessed with two different scales.

The Aesthetic Component as part of the IOTN is generally used to measure treatment need from the aesthetic point of view (Richmond *et al.*, 1992a). It is known, however, from other studies that dental aesthetics is a different entity from facial aesthetics and that background facial attractiveness appears to dominate (Shaw *et al.*, 1991). Therefore a comparison was made with a facial attractiveness scale, which was developed by Peerlings *et al.* (1995). In using this scale the judges are instructed to rate the aesthetics of the face in total, and not only the aesthetics of the eyes, mouth, or nose, for example. Of course, such a photograph is only a random indication picture of the test person's facial attractiveness at that particular point in time. However, it has shown in earlier studies that photographic records provide valid, reproducible, and representative ratings of facial aesthetics (Melamed and Moss, 1975; Tedesco *et al.*, 1983b; Howells and Shaw, 1985; Cohn *et al.*, 1986).

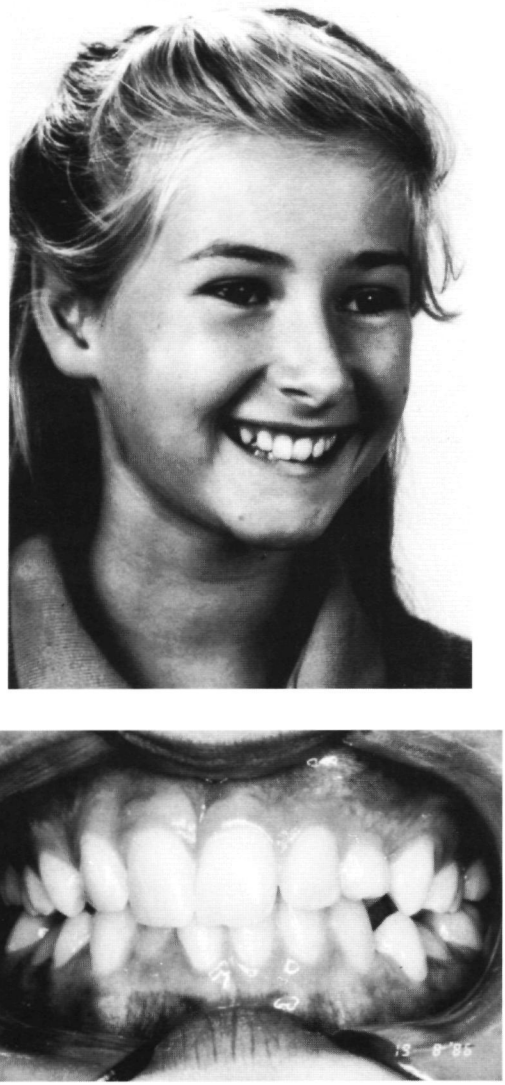

Figure 2-1: *3/4 facial and intra-oral photographs prior to treatment. The facial aesthetic score was 170 and the dental aesthetic score was 6.*

Figure 2-2: *Post-treatment 3/4 facial and intra-oral photographs for the same patient. The facial aesthetic score decreased to 110 and the dental aesthetic score improved to 2.*

In our sample dental and facial aesthetics were significantly correlated only in male patients at the pretreatment phase. From other studies, it is known that male patients seeking orthodontic treatment have more severe malocclusions than females (Espeland and Stenvik, 1991; Holmes, 1992). Generally speaking in this sample, it was true that male patients had a more severe arch length discrepancy, a larger overjet and overbite, and a larger median diastema. It is possible that the relationship between dental and facial aesthetics is only clear when a more severe malocclusion is present. Several other significant correlations were found between facial and dental aesthetics, but they showed no consistent pattern.

Our study shows that facial aesthetics improved in the group treated orthodontically during the observation period. Facial aesthetics did not change significantly in the group that was already in the post-treatment phase and who therefore did not undergo active orthodontic treatment during the observation period. The same holds true for dental aesthetics. This means that the changes after treatment were minor.

Table 2-3: *Increments (mean and sd) for FA and DA. Significance was tested by the paired t-test.*

	pretreatment/ post-treatment (A1/A2)				post-treatment/ postretention (B1/B2)			
	n	mean	sd	sig.	n	mean	sd	sig.
FA	72	11.2	18.9	.001	72	1.9	21.1	0.4
DA	69	-5.2	2.0	.001	72	-.04	1.5	0.8

No significant correlations were found between the changes in facial and dental aesthetics in both groups. The findings are illustrated in Figure 2-1 and Figure 2-2. This patient shows an improvement in the dental aesthetics in the post-treatment stage compared with the pretreatment stage. The scores

according to the AC of the IOTN were 2 and 6 respectively. For the same patient the score according to the FA scale was 170 at the pretreatment and 110 at the post-treatment stage. This means that dental aesthetics improved, while at the same time the effect on facial aesthetics was negative. This suggests that facial and dental aesthetics as measured in this study are influenced by different factors. For example, several studies have shown that a convex profile and a vertical facial pattern result in less positive ratings for facial aesthetics (Cox and Van der Linden, 1971; Prahl-Andersen *et al.*, 1979; Lundström *et al.*, 1989; Peerlings, 1992). However, those features will probably not affect the dental aesthetic score, because they are not visible on dental casts. Therefore, in an index that determines orthodontic treatment need, a dental as well as a facial aesthetic scale should be incorporated, in order to obtain an adequate judgement of the aesthetic impairment associated with a certain malocclusion.

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Chapter 3

Assessment of biological changes in a non-orthodontic sample using the PAR index

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3.1 Abstract

The aim of the present study was to assess the effect of normal growth and development on the PAR index between 12 and 22 years of age.

The sample consisted of 49 non-orthodontic subjects (24 male and 25 females) from the Nijmegen Growth Study. The mean age at the first observation was 12.2 ± 0.7 years and at the second observation 22.1 ± 0.6 years. The dental casts at these ages were scored with the PAR index. The influence of the Angle classification and malocclusion severity on changes over time in the PAR score were evaluated. The mean changes in the PAR scores over time between cases which have more than 30% improvement to those which have less than 30% improvement were calculated.

The results indicate that there were no significant differences between the mean PAR score at 12 years of age (12.20 ± 0.91) and at 22 years of age (12.45 ± 1.28), but there where relevant differences in individual cases. The changes were irrespective of the Angle classification or treatment need. Changes over time in the weighted PAR score were mainly correlated to changes in the anterior crossbite and the overjet. This correlation may be influenced, however, by the applied weighting factor for those occlusal traits.

3.2 Introduction

The Peer Assessment Rating index (PAR), introduced by Richmond *et al.* (1992a) has become widespread, especially in Europe. The PAR index was developed to assess outcome of orthodontic treatment. The index provides an overall score for alignment and occlusion. It is applied on an individual's pre- and post-treatment dental casts and the difference between the pre- and post-treatment scores reflects the degree of improvement and hence the success of orthodontic treatment (Shaw *et al.*, 1991).

The outcome of orthodontic treatment, however, is not purely the result of orthodontic mechanical interventions alone. Twin studies have shown that occlusal features such as overjet, overbite, buccal segment relation, and tooth position are influenced by environmental factors (Corruccini and Potter, 1980; Potter *et al.*, 1981). Furthermore, Heikinheimo *et al.* (1982) showed that 38 per cent of the children who were identified as needing orthodontic treatment at 7 years of age, were found not to need any orthodontic treatment when reexamined at 10 years of age. This shows that in young individuals physiological growth is an important factor, that also might have a positive or a negative influence on orthodontic treatment outcome. The implant marker studies of Björk indicated already that during growth and development of the face, compensatory adaptations in the development of the occlusion occur which tend to even out positional changes between the jaws. If such compensation is insufficient or does not occur at all, a defective occlusion and space anomalies will result (Björk and Skieller, 1972). Schudy emphasised that "we must not think of the growth of the jaws merely as a concentric enlargement of the face, but as definite amounts of growth in millimetres occurring in specific areas resulting in specific effects on overbite and overjet" (Schudy, 1965).

In a longitudinal study on anterior vertical overbite from 8 to 20 years of age Bergersen (1988) found that overbite established at eight years of age was most likely to increase until 12 years of age and then to decrease from 12 to 18 years. No difference was found between the mean overbite at 8 years and at 18 years of age, but individual changes varied greatly. Maj and Luzi

(1967) showed that overjet and overbite tended to decrease between 9 and 17 years of age, especially the overjet. However, the changes were minor and not clinically relevant.

Besides changes in overjet and overbite during normal growth and development of the face, there are changes in maxillary and mandibular arch length too. In fifty subjects followed longitudinally between the age of 13 and 18 years Richardson (1995) found an average increase in lower arch crowding of 2.36 mm. Comparing individuals who have a greater arch length discrepancy to individuals who have a lesser arch length discrepancy at early adulthood, the former tend to have a greater reduction over time in the available arch length (Bishara *et al.*, 1989; Bishara *et al.*, 1994).

From the above mentioned studies it can be anticipated that the PAR score might be affected by normal biological changes without any orthodontic treatment at all. In the literature only very few studies could be found, that assessed the influence of physiological growth and development on PAR index scores. In two abstracts of Afsharpanah *et al.* (1995, 1996) the effects of normal growth and development on the PAR index scores were described, using longitudinal data of orthodontically untreated subjects enrolled in the Bolton Brush Growth Study. It was reported that no subjects were "greatly improved", while 16% to 22% of the subjects were considered as "improved" according to the definitions of Richmond *et al.* (1992b).

The aim of our study was to assess the biological changes in a non-orthodontic sample between 12 and 22 years of age using the PAR index.

3.3 Material and methods

3.3.1 Subjects

The Nijmegen Growth Study, which was designed as a mixed-longitudinal study to provide information concerning the normal growth and development of Dutch children from 4 to 14 years of age, started with 486 children, randomly selected from municipality records, and finished with the complete records of 406 children (Prahl-Andersen *et al.*, 1979). At the age of 22 years

a sub-cohort was recalled for dental screening, leading to 49 subjects (24 male and 25 female) fitting the inclusion criteria, which were: the presence of two standardised dental casts (age 12 and 22), not orthodontically treated, and the presence of a complete permanent dentition mesial to the first molar. The mean age at the first observation was 12.2 $\pm$ 0.7 years and at the second observation 22.1 $\pm$ 0.6 years.

3.3.2 Methods

The PAR index was used to evaluate the two dental casts of the same subject (Richmond *et al.*, 1992a). At least a 30 per cent reduction in PAR score should be reached to consider a case as "improved". A change of 22 PAR points is required for a case to be considered as "greatly improved" (Richmond *et al.*, 1992b). Furthermore, at the initial dental cast the individuals were classified according to the Angle classification and according to treatment need using the dental health component (DHC) of the IOTN (Brook and Shaw, 1989). Grade 1 up to 3 were taken together representing a group with a mild malocclusion and grade 4 and 5 joined in another group representing a severe malocclusion.

To assess the reproducibility of the evaluation methods, standard orthodontic study models (pretreatment and 5 years postretention) of 18 patients were measured twice by two observers, using the PAR and the IOTN indices. The time interval between the two assessments was at least three months.

3.3.3 Statistics

Mean and standard deviations of weighted PAR scores were calculated. The influence of the Angle classification and malocclusion severity (IOTN) were evaluated by the t-test. The mean changes in the PAR scores of different occlusal traits (PAR subscores) were studied for cases which had more than 30% improvement and those who had less than 30% improvement (Corruccini and Potter, 1980) using the t-test. To assess which occlusal trait was most responsible for the change over time in the PAR scores, Pearson's correlation coefficients were calculated between the change in total PAR

score and the change in score of a specific occlusal trait.

3.4 Results

The intra-observer measurement error was 0.85 PAR points and 0.13 points for the IOTN scale. The inter-observer measurement error was 1.94 for the PAR and 0.17 for the IOTN. This showed a high level of reproducibility.

In Table 3-1 mean weighted PAR scores and standard deviations are given at 12 years and at 22 years of age for Class I and Class II cases separately. When comparing Class I and Class II cases no significant differences were found between the mean PAR scores at the first observation and at the second observation.

Table 3-1: *Comparison of the mean and standard deviations of weighted PAR scores at 12 and 22 years of age for Angle Class I and Class II cases.*

observation stage	total group (n = 49)	Angle I (n = 39)	Angle II (n = 10)	P value I vs II
PAR at 12 yrs	12.2 ± 6.4	11.9 ± 6.2	13.4 ± 7.2	0.5
PAR at 22 yrs	12.4 ± 9	12.9 ± 9.2	10.8 ± 8.1	0.5

P value = t-test

According to the classification of Richmond *et al.* (1992b) there were no cases with a greatly improved PAR score (more than 22 points reduction between the 1st and 2nd observation). 31 cases (63%) showed no improvement or became worse (less than 30% reduction in the PAR scores between the first and the second observation). 18 cases (37%) were improved (more than 30% reduction in the PAR scores).

Table 3-2 shows the mean changes in PAR score between 12 and 22 years of age. The cases are classified according to the Angle classification and the treatment need (IOTN) at 12 years of age. The mean changes varied from -0.09 to 2.60. There were no significant differences in the PAR scores changes over time neither when Class I and Class II cases were compared nor when the cases were compared according to the malocclusion severity.

Table 3-2: *Comparison of changes in the PAR score (observation at 12 years minus observation at 22 years) between Class I and II cases and between mild and severe malocclusions in a two-way ANOVA.*

variable	category	n	mean change in PAR score	P value
Angle Class	Class I	39	-0.97 ± 7.80	0.18
	Class II	10	2.60 ± 4.72	
IOTN need	DHC 1, 2, 3	44	-0.09 ± 7.60	0.67
	DHC 4, 5	5	-1.60 ± 5.86	

The PAR index contains seven different occlusal traits (subscores) (Table 3-3). All changes in subscores except for the overbite were significantly different between cases which have more than 30% improvement and those which have less than 30% improvement.

Several significant correlations were found between the total changes in the PAR score and the changes in the subscore. The highest were found for the anterior crossbite ($r = 0.67$; $p < 0.001$) and overjet ($r = 0.60$; $p < 0.001$). Multiple regression analysis showed the same i.e. the anterior crossbite and overjet scores were the most responsible subscores for the changes in the PAR scores over time.

Table 3-3: *Comparison of changes in the PAR score of different occlusal traits (observation 1 minus observation 2) between the cases that have less than 30% improvement and the cases that have more than 30% improvement in the PAR score. Correlation coefficients (r) between the amount of change of the total PAR score and the amount of change in a specific occlusal trait (PAR subscores) are given.*

occlusal trait (subscore)	mean change ± sd in PAR subscore: PAR improvement < 30%	PAR improvement > 30%	P value (t-test) n = 31	r n = 18
contactpoint displacement	-1.8 ± 2.6	0.4 ± 1.3	0.002	0.44
lateral occlusion	-0.4 ± 1.7	1.6 ± 1.5	0.000	0.49
overjet	0.1 ± 0.5	0.6 ± 0.5	0.001	0.60
anterior crossbite	-0.3 ± 0.7	0.0 ± 0.0	0.042	0.67
overbite	0.0 ± 0.6	0.2 ± 0.6	0.192	0.14
open bite	-0.2 ± 0.6	0.1 ± 0.2	0.049	0.45
centre line	-0.1 ± 0.4	0.2 ± 0.4	0.008	0.38

3.5 Discussion

Comparison of the mean PAR scores between the first observation at 12 years of age and the second observation at 22 years of age showed no significant differences, but there where relevant differences in individual cases (Fig. 3-1 and 3-2). These individual differences (either positive or negative) can be explained by the variation in genetic or environmental factors or their combination (Corruccini and Potter, 1980; Potter *et al.*, 1981; Heikinheimo *et al.*, 1982; Björk and Skieller, 1972).

Although our study was undertaken to assess the effect of normal growth and development on the PAR index, it seems to be that our findings match with other studies that were done to assess the influence of growth and development on different occlusal traits. In our study we found that the occlusal trait most responsible for the deterioration of the mean PAR score, in the cases which have a lower tendency to improve (less than 30%

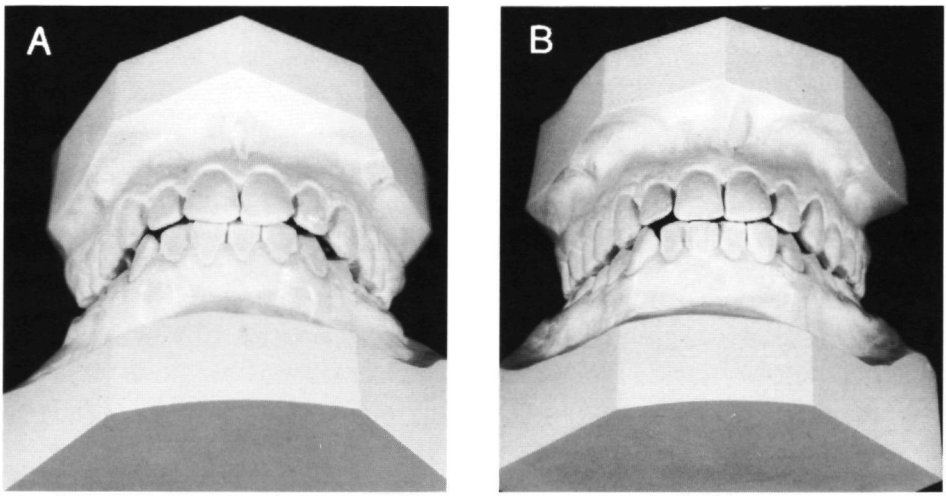

Figure 3-1: *Oblique frontal photographs of dental casts of the same person show the physiological deterioration as measured with the PAR. a. At 12 years of age (PAR score: 1); b. At 22 years of age (PAR score: 16).*

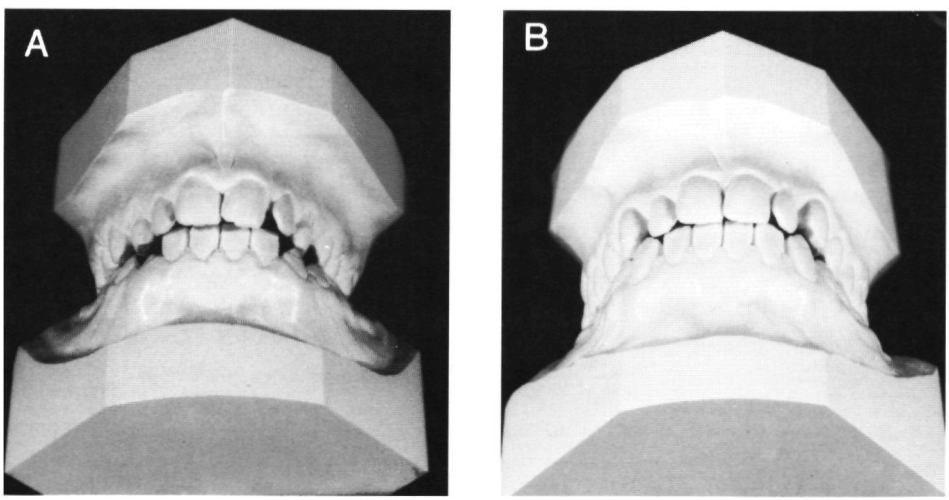

Figure 3-2: *Oblique frontal photographs of dental casts of the same person show the physiological improvement as measured with the PAR. a. At 12 years of age (PAR score: 11); b. At 22 years of age (PAR score: 2).*

improvement), is the crowding and especially the crowding of the lower incisors. This is in agreement with the findings of Bishara *et al.* (1989, 1994). In the cases that have a higher tendency to improve (more than 30% improvement) the occlusal traits most responsible for the improvement of the mean PAR scores, are the overjet and the lateral occlusion. Schudy *et al.* (1965) and Maj and Luzi (1967), indicate in their findings too that the overjet tends to decrease with time.

The improvement in the lateral occlusion can be partly explained by the fact, that the PAR index measures the sagittal lateral occlusion according to the interdigitation of the cusps. So, there is no difference between occlusal neutro-relation and a full premolar width Class II or Class III relationship. In the present study the first observation was done at 12 years of age. At that time some buccal teeth may have been partly erupted and may not have been in full intercuspation. By the time of the second observation at 22 years of age full interdigitation may have been reached which gives a lower PAR score.

The change over time in the scores for the anterior crossbite or the overjet, either positively or negatively, are the most important factors responsible for the change in the PAR score over time. This may be due to the weighting used in the calculation of the overall PAR value, because anterior crossbite and overjet are multiplied by six according to the British weighting standard, and the correlation might change if the weighting value is altered.

Afsharpanah *et al.* (1995) showed that normal growth and development has a 16% chance of achieving at least a 30% reduction in the PAR scores. The average age at the first observation was 12.4 $\pm$ 0.5 years and at the second observation 14.5 $\pm$ 0.6 years. In their second study (Afsharpanah *et al.*, 1996) they included one more observational stage at the mean age 16.4 $\pm$ 0.5 years. It was found that normal growth and development had a 22% chance of achieving at least a 30% reduction in the PAR scores. In our study with the final observation at 22 years of age a 37% chance of achieving at least 30% reduction in the PAR score was found. When we compare this percentage with that of Afsharpanah *et al.* (1995, 1996) it can be seen that a

larger interval between the first and second observation will lead to a higher chance to find the dental condition improved i.e. achieving more than 30% reduction in the PAR score. However, this may be an overestimation of the changes over time caused by normal biological growth. This overestimation is due to the fact that many retrospective studies aim to describe natural growth. Then inclusion criteria are mostly applied afterwards (at the oldest age and not at the youngest age), the same was done in the present study. This type of design has been used before in many orthodontic studies (Lundy and Richardson, 1995; Judy *et al.*, 1995; Bishara *et al.*, 1995; Blanchette *et al.*, 1996) but it may not be regarded as a prospective historical cohort study, since persons may escape from the cohort due to treatment. Only changes over time in retrospect can be studied, which are an overestimation of changes in a cohort study. This overestimation of changes over time is due to the fact that persons who change much, are more likely to be treated than stable persons.

3.6 Conclusions

From this study it may be concluded that the mean PAR score was not affected by physiological growth between 12 and 22 years of age irrespective of the Angle classification or the malocclusion severity. Although the mean PAR score at 12 and 22 years remained the same, there were, however, clinically relevant changes in individual cases. Changes over time in the weighted PAR score were most correlated to change in the anterior crossbite and the overjet. This correlation may change, however, when using another weighting factor for those occlusal traits.

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Chapter 4

Orthodontic treatment need prior to treatment and five years postretention

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4.1 Abstract

A random sample of 920 patients (400 male and 520 females) from the Department of Orthodontics and Oral Biology, University of Nijmegen (the Netherlands), were included in this study. Dental casts were evaluated using the Index of Orthodontic Treatment Need (IOTN) at the pretreatment (TP) and 5 years postretention stages (T5). The mean age at TP was 12.2 $\pm$ 3.0 years and at T5 21.6 $\pm$ 3.1 years. At TP and T5 the Aesthetic Component (AC) and the Dental Health Component (DHC) were assessed. The difference between TP and T5 was compared for males and females and tested by the t-test. The changes in AC, DHC and treatment need categories were described at TP and at T5. Based on the combined AC and DHC treatment need categories 83% of the patients was falling in the "Definite need" prior to treatment and 10% of the treated patients was categorised as "Definite need" 5 years postretention.

No significant differences were found between males and females for the change in AC and DHC between TP and T5. The results indicate that the policy used in the department for patient selection is given priority to the patients with a high treatment need. The results also provide a general impression of treatment outcome utilising the IOTN by analysing the change in the treatment need categories.

4.2 Introduction

In times of restricted financial resources and limited manpower, patients who need orthodontic treatment should be prioritized in order that the most needy ones should be treated and that, when treatment is undertaken, the malocclusion should be corrected to an appreciable extent (Brook and Shaw, 1989; Moyers, 1990; Shaw *et al.*, 1991b and 1991c; Holmes, 1992; Richmond *et al.*, 1992a; Hill, 1992).

Several studies have assessed the need for orthodontic treatment before and after treatment. A report on child dental health in England and Wales (Todd and Dodd, 1985) found that 30 per cent of 15 years olds who had previously received orthodontic treatment was in need of farther treatment. Mohlin (1982) suggested that the need in a group of Swedish women with an age range 20 to 45 years was still high as much of the orthodontic treatment was provided 20 to 30 years ago, probably as a compromise owing to limited orthodontic resources. The treatments had probably reduced the severity of malocclusions, but had not eliminated them. However, Myrberg and Thilander, (1973) have reported mild to severe relapse in 24 per cent of orthodontically treated children, 1 to 5 years after treatment.

Over the past few years the need to determine patients with high orthodontic treatment need with an objective tool (index) became obvious. Three criteria for an index which measures orthodontic treatment need should be considered: objective measures of dental status, indication of the patient's recognition of need for treatment and recognition by society (Prahl-Andersen, 1978; Cons *et al.*, 1989). Two indices were developed which seem to fulfil these requirements. Firstly, the Dental Aesthetic Index (DAI) which links the people's perceptions of aesthetics with anatomic trait measurements by regression analysis to produce a single score obviating the need (Cons *et al.*, 1986; Jenny and Cons, 1996a; Jenny and Cons, 1996b). Secondly, the Index for Orthodontic Treatment Need (IOTN), which contains two separate components to record the aesthetic impairment caused by the malocclusion and the dental health and functional indications for treatment (Brook and Shaw, 1989; Shaw *et al.*, 1995). This study is limited to the IOTN index as a

GRADE 5 (Need treatment)
5.i Impeded eruption of teeth (except for third molars) due to crowding, displacement, the presence of supernumerary teeth, retained deciduous teeth and any pathological cause.
5.h Extensive hypodontia with restorative implications (more than 1 tooth missing in any quadrant) requiring pre-restorative orthodontics.
5.a Increased overjet greater than 9 mm.
5 m Reverse overjet greater than 3 5 mm with reported masticatory and speech difficulties.
5.p Defects of cleft lip and palate and other craniofacial anomalies
5 s Submerged deciduous teeth.

GRADE 4 (Need treatment)
4 h Less extensive hypodontia requiring prerestorative orthodontics or orthodontics space closure to obviate the need for a prosthesis
4 a Increased overjet greater than 6 mm but less than or equal to 9 mm
4 b Reverse overjet greater than 3.5 mm with no masticatory or speech difficulties.
4 m Reverse overjet grater than 1 mm but less than 3 5 mm with recorded masticatory and speech difficulties.
4 c Anterior or posterior crossbites with greater than 2 mm discrepancy between retruded contact position and intercuspal position
4 l Posterior lingual crossbite with no functional occlusal contact on one or both buccal segments.
4 d Severe contact point displacements greater than 4 mm.
4 e Extreme lateral or anterior open bites greater than 4 mm.
4.f Increased and complete overbite with gingival or palatal trauma.
4 t Partially erupted teeth, tipped and impacted against adjacent teeth
4 x Presence of supernumerary teeth.

GRADE 3 (Borderline need)
3.a Increased overjet greater than 3 5 mm but less than or equal to 6 mm with incompetent lips.
3.b Reserve overjet greater than 1 mm but less than or equal to 3 5 mm.
3.c Anterior or posterior crossbites with greater than 1 mm but less than or equal to 2 mm discrepancy between retruded contact position and intercuspal position
3 d Contact point displacements greater than 2 mm but less than or equal to 4 mm.
3.e Lateral or anterior open bite greater than 2 mm but less than or equal to 4 mm
3.f Deep overbite complete on gingival or palatal tissues but no trauma

GRADE 2 (little)
2 a Increased overjet greater than 3.5 mm but less than or equal to 6 mm with competent lips.
2 b Reverse overjet greater than 0 mm but less than or equal to 1 mm.
2 c Anterior or posterior with less than or equal to 1 mm discrepancy between retruded contact contact position and intercuspal position
2.d Contact point displacements greater than 1 mm but less than or equal to 2 mm.
2.e Anterior or posterior openbite greater than 1 mm but less than or equal to 2 mm.
2 f Increased overbite greater than or equal 3.5 mm without gingival contact.
2 g Pre-normal or post-normal occlusions with no other anomalies (includes up to half a unit discrepancy)

GRADE 1 (None)
1. Extremely minor malocclusions including contact point displacements less than 1 mm.

Figure 4-1: *The dental health component of the index of orthodontic treatment need IOTN (Richmond et al., 1992a).*

tool to categorise patients seeking orthodontic treatment because of its recent popularity in the Netherlands.

Several short term studies reported about treatment need in selected populations using the IOTN index (O'Brien *et al.*, 1993; Richmond and Andrews, 1993; Holmes and Willmot, 1996). Fox and Chadwick (1994) described the treatment need at one year postretention using the IOTN. A change in treatment need as measured by the Aesthetic and the Dental Health Components of the IOTN was observed in 51 cases followed until 16 months out of retention. The results indicated that the Aesthetic Component deteriorated only slightly once the cases were out of retention. On the other hand 10 cases out of 51 showed a definite need for treatment when they were out of retention. Richmond and Andrews (1993) applied the IOTN to the pre- and post-treatment dental casts of 220 patients from Norwegian orthodontists. On average, the AC scores started at 7 and finished at 2. The DHC commenced in the "Need for treatment" category and finished in the "No need" category. Richmond *et al.*(1994) assessed the need for orthodontic treatment before and after treatment in 1225 cases. The mean AC score was 6.9 at pretreatment and 3.2 at post-treatment while the DHC score was 4.0 $\pm$ 0.6 and was 3.0 $\pm$ 0.9 respectively.

As stated earlier all studies mentioned above deal with short term outcome of orthodontic treatment. There are no published reports which evaluate the treatment need prior to and several years after orthodontic treatment. The aim of this study was to assess the treatment need before treatment and at five years postretention.

4.3 Material and methods

4.3.1 Material

The archives of the Department of Orthodontics and Oral Biology, University of Nijmegen (The Netherlands), contain records of 2368 patients having a pretreatment as well as post-treatment dental casts at different stages. From the cases which had dental casts at pretreatment (TP) and at five years

postretention (T5) (n = 1167), a random sample (based on alphabetical sequence on patients family name) of 920 patients (400 male and 520 females) was included in this study. Standard orthodontic dental casts were evaluated at (TP) and at (T5). The mean age at TP was 12.2 ± 3.0 years and at T5 was 21.6 ± 3.1 years.

4.3.2 Methods

The Index Of Treatment Need (IOTN) which was introduced by Brook and Shaw (1989), and modified by Richmond *et al.* (1992a) was used to score dental casts at TP and T5 of the same patient. The index incorporates two components, the Dental Health Component (DHC) and the Aesthetic Component (AC). The DHC records the various occlusal traits of a malocclusion. There are five grades ranging from grade 1 "No need for treatment" to grade 5 "Very great need" (Fig. 4-1). Only the worst occlusal feature is recorded. It would be reasonable to expect that after appliance therapy the patients should fall into the "No need for treatment" category. There are two ways of recording the DHC. The first is to record the grade only and in the second way, the initiating feature would be recorded. In this study the first mentioned method was performed using the dental casts protocol (Brook and Shaw, 1989; Buchanan *et al.*, 1994). The Aesthetic Component consists of a scale of ten black and white photographs showing different levels of dental attractiveness (Evans and Shaw, 1987). Grade 1 represents the most and grade 10 the least attractive arrangements of the anterior teeth.

The Dental Health Component was categorised into three groups: 1 and 2: no need for treatment; 3: moderate/ borderline need for treatment; 4 and 5: need for treatment. The Aesthetic Component grading can be split into three main groups: grades 1-4: no need for treatment; grades 5-7: moderate/ borderline need for treatment; grades 8-10: need for orthodontic treatment.

Three examiners were incorporated in this study. To determine the measurement error and to assess the intra- and inter-observer agreement, the AC score and the DHC score of a random sample of dental casts of 18 patients were assessed by the three observers. For each patient two different

dental casts one at TP and one at T5 were measured twice. The time interval between the two intra-observer measurements was at least 3 months.

4.3.3 Statistics

The magnitude of the duplicate error was calculated for the DHC and the AC scores. Systematical differences between observers were tested by the paired t-test. The inter- and intra-observer reliability was expressed as the Pearson's correlation coefficients between duplicate measurements.

The AC and the DHC at TP and at T5 and the difference between TP and T5 were compared for males and females and tested by the t-test. The changes in AC, DHC, and treatment need categories for the AC and DHC were described at TP and at T5.

4.4 Results

4.4.1 Reproducibility

No significant systematical differences were found between examiners (paired t-test). The reproducibility of the IOTN index is presented in Table 4-1, indicating a high level of reproducibility.

Table 4-1: *Intra- and inter-observer measurement error and reliability of the measurement of the IOTN index.*

type of agreement	error (n = 108)	range of measurement / remeasurement correlation (n = 18)
AC - intra	0.34	0.96 - 0.97
AC - inter	0.55	0.89 - 0.96
DHC - intra	0.13	0.92 - 1.0
DHC - inter	0.17	0.89 - 1.0

4.4.2 Comparison of AC and DHC

The mean AC score was 7.8 ± 1.5 and the mean DHC was 4 ± 0.8 at pretreatment (TP). It decreased to 3.6 ± 1.7 for the AC and to 2.5 ± 0.7 for the DHC at 5 years postretention (T5). Significant differences were found between male and female for both AC and DHC at pretreatment (TP), and for the AC only at 5 years postretention (T5), being higher for males. No significant differences were found between males and females when the difference in AC and DHC between TP and T5 was tested (Table 4-2).

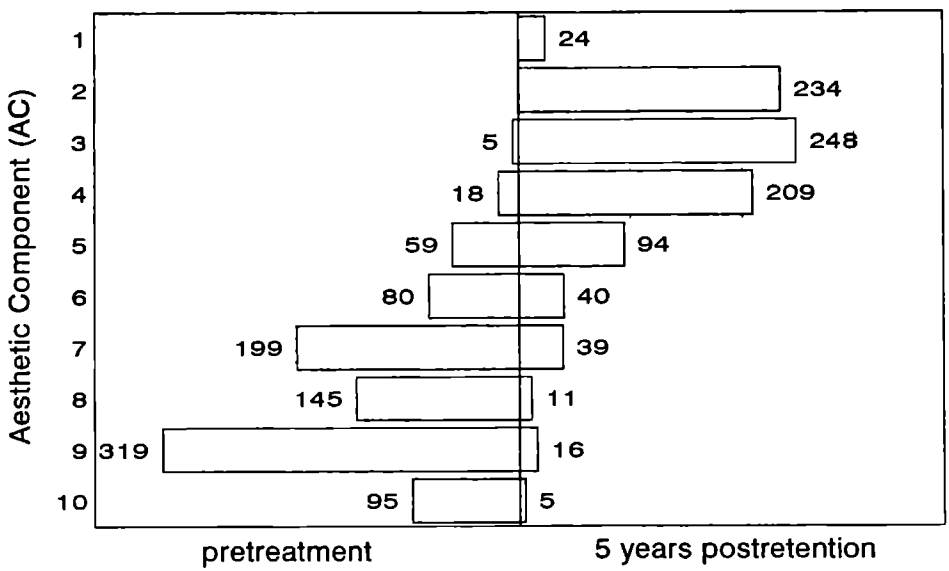

Figure 4-2: *Distribution of the patients (n = 920) according to the Aesthetic Component (AC) of the IOTN at the pretreatment stage and 5 years postretention.*

Figure 4-2 shows the distribution of patients over the 10 grades of the AC at the pretreatment stage and 5 years postretention. The majority of the patients was in a higher range of the AC at TP (not attractive arrangement of the anterior teeth) and in a lower range of AC at T5.

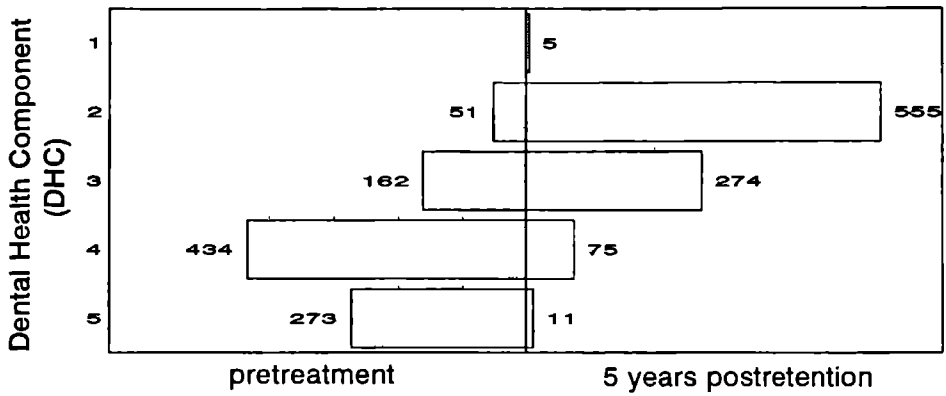

Figure 4-3: *Distribution of the patients (n = 920) according to the Dental Health Component (DHC) of the IOTN at the pretreatment stage and 5 years postretention.*

Figure 4-3 shows that there were more cases with high DHC scores (great need for treatment) at TP as compared to T5.

Table 4-3 shows the change in the percentage of patients in the different treatment need categories of the AC and DHC between TP and T5. At the start of treatment 60.8% of the patients had a clear aesthetic treatment need. Based on the DHC 76.8% of the sample had a high need for treatment. Five years postretention 3.5% of the patients had an aesthetic treatment need, while 9.3% had a clear need for orthodontic treatment based on dental features.

Table 4-4 shows the treatment need categories based on the combined treatment need of the AC and DHC. At the start of treatment 82.7% of the patients had a clear treatment need based on dental and aesthetic features. Five years postretention 10.4% of the patients such a clear treatment need.

4.5 Discussion

In this study the orthodontic treatment need was assessed for orthodontic patients referred to a university clinic (postgraduate and staff) before treatment and at 5 years postretention utilising the IOTN. Inclusion in the study was based on alphabetical sequence on the patients family name. This method can be considered as an acceptable way for sampling, since malocclusions are evenly distributed among the names of the Dutch population. In a pilot study the distribution of patients was investigated in all orthodontic offices (6 orthodontists) in the Nijmegen region.

Table 4-2: *Aesthetic components (AC) and dental health components (DHC) at pretreatment (TP), five years postretention (T5) and the difference between TP and T5 compared for males and females.*

stage		total (n = 920) mean ± sd	male (n = 400) mean ± sd	female (n = 520) mean ± sd	p-value male/ female
TP	AC	7.8 ± 1.5	8.0 ± 1.5	7.8 ± 1.5	0.019
	DHC	4.0 ± 0.8	4.1 ± 0.8	3.9 ± 0.8	0.004
T5	AC	3.6 ± 1.7	3.8 ± 1.7	3.5 ± 1.7	0.004
	DHC	2.5 ± 0.7	2.5 ± 0.7	2.5 ± 0.7	0.203
TP-T5	AC	4.2 ± 2.0	4.2 ± 2.1	4.3 ± 2.0	0.528
	DHC	1.5 ± 1.0	1.6 ± 1.0	1.5 ± 1.0	0.139

P-value = t- test.

In this sample (n = 1438) the mean AC was 7.3 and the mean DHC was 3.7. So, the sample of the present study, with a mean of 7.8 for the AC and 4.0 for the DHC, can be considered as representative for the orthodontic patients in the Nijmegen region.

The percentage of patients which were categorized at the pretreatment stage as having "Definite need" was 77% according to the DHC and 61% according to the AC. Only 18% was categorized as "Borderline need" according to the DHC and 37% according to the AC. 5.5% and 2.5% were categorized as "No need" according to the DHC and AC respectively.

Table 4-3: *The percentage of patients (number) according to the treatment need categories of the DHC crosstabulated by the treatment need categories of the AC at TP and T5 separately.*

		DHC					
		little (0)		borderline (1)		high (2)		Total	
		%	(n)	%	(n)	%	(n)	%	(n)
	0	0.3	(3)	1.0	(9)	1.2	(11)	2.5	(11)
TP	1	4.8	(44)	11.2	(103)	20.8	(191)	36.7	(338)
	2	0.4	(4)	5.4	(50)	54.9	(505)	60.8	(559)
	Total	5.5	(51)	17.6	(162)	76.8	(707)	100	(920)
AC									
	0	54.9	(505)	20.2	(186)	4.6	(42)	77.7	(715)
T5	1	5.8	(53)	8.7	(80)	4.3	(40)	18.8	(173)
	2	0.2	(2)	0.9	(8)	2.4	(22)	3.5	(32)
	Total	60.9	(560)	29.8	(274)	9.3	(86)	100	(920)

0 = little or no need for treatment
1 = borderline need for treatment
2 = high need for treatment

However, other factors than the presence of an obvious malocclusion also determine whether or not an individual will have orthodontic treatment. Firstly, a small percentage of patients in the low category of treatment need was accepted for the purpose of postgraduate teaching as was also described in the study of Holmes and Willmot (1996). Secondly, the eventual decision for treatment reflects a combination of features and aspirations of the patient and/or parents and the practitioner (Shaw *et al.*, 1991a). On the other hand, a patient may have a low treatment need according to the AC and a high treatment need according to the DHC or the opposite.

During the years the patient intake of the department was done by three orthodontists and no treatment priority index was used. The results of this study show that the overall mean of the patients that were treated was 7.8 for the AC and 4 for the DHC. This indicates that the policy for patient selection at the orthodontic department is very well matching with the orthodontic treatment priority as measured with an objective tool such as the IOTN index.

Table 4-4: *The percentage of patients (number) based on the combined treatment need categories of the AC and DHC at TP and T5.*

		T5					
		little (0)		borderline (1)		high (2)		Total	
		%	(n)	%	(n)	%	(n)	%	(n)
TP	0	0.3	(3)					0.3	(3)
	1	10.2	(94)	5.9	(54)	0.9	(8)	17	(156)
	2	44.4	(408)	28.8	(265)	9.5	(88)	82.7	(761)
	Total	54.9	(505)	34.7	(319)	10.4	(96)	100	(920)

Comparison of the results of Richmond *et al.* (1994) with our results indicates that the need for orthodontic treatment at the pretreatment stage according to the AC was higher in our sample. The mean AC was 7.8 in our

sample and 6.9 in Richmond's sample. The need according to the DHC component was similar for both samples being 4. Surprisingly, the need for treatment at the post-treatment stage according to the DHC was higher in Richmond's study, being 3.0 ± 0.9 even while the observation period was different being immediately post-treatment in Richmond's study and 5 years postretention in our study.

There were significant differences between male and female in the AC and DHC prior to treatment and in the AC at 5 years postretention. However, these differences were small and are considered as clinically irrelevant especially, as there were no significant differences between the increment of the AC and the DHC between TP and T5.

At the start of treatment 82.7% of the patients had a clear need for orthodontic treatment, both from the dental and the aesthetic point of view. Five years postretention only 10.4% of the patients had such a clear treatment need. These results are much better than the results of Burgersdijk *et al.* (1991) where 44% of the patients who had an orthodontic treatment showed an objective need for orthodontic treatment at the time of the survey. In that study, however, the time interval between the end of orthodontic treatment and the time of the observation was not clear. Furthermore no distinction was made between patients treated by orthodontists and patients treated by general practitioners.

The largest part of the patients with a clear treatment need 5 years postretention came from the category of patients which had already a high treatment need at the start of treatment. A few patients with a low treatment need prior to treatment ended up with a high treatment need after treatment; This was only the case for 8 patients. In some cases, however, a compromise treatment plan may satisfy the patients need while the occlusal feature as it measured with the IOTN is deteriorating. The mean age at 5 years postretention was 21.6 ± 3.1 years which may indicate that some patients may have developed tertiary crowding. This may give a completely different indication for treatment need than the indication at the start of treatment, while the results of the orthodontic treatment for the original problem may be relatively stable.

The IOTN was developed to measure the treatment need by recording the worst malocclusion feature. It was not designed to measure treatment outcome in a very detailed way. It is unlikely that one index alone can meet all criteria for prioritizing orthodontic patients and can measure treatment outcome in an accurate and simple manner. The PAR index was developed to measure occlusal changes due to treatment (Richmond *et al.*, 1992b). Therefore, the complete sample from the orthodontic department of the University of Nijmegen will be evaluated with the PAR index.

4.6 Conclusion

Before treatment 83% of the patients who started treatment had an objective need for orthodontic treatment based on dental and aesthetic features. 10% of the treated patients still showed a definite need 5 years postretention. The results indicated that the policy used in the department for patient selection gives priority to patients with a high treatment need. The results also provide a general impression of treatment outcome utilising the IOTN by analysing the change in the treatment need categories.

4.7 Literature

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Chapter 5

Occlusal outcome of orthodontic treatment

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5.1 Abstract

Aim of this study was to evaluate the overall quality of orthodontic treatment in a university clinic. Dental casts of 1870 patients (799 male and 1071 females) were evaluated at the pretreatment and post-treatment stages using the PAR index. The mean age at the pretreatment stage was 13 ± 4.1 years and at the post-treatment stage 16 ± 3.9 years. At both stages mean and standard deviation of the (weighted) PAR score were calculated as well as the percentage reduction in the weighted PAR score. The percentage of perfect scores (score = 0) of the different components of the PAR index was calculated. The analysis of variance and t-test were applied to compare the quality of treatment for the variables treatment period and gender respectively.

The mean weighted PAR score was 27.6 ± 10, and 7.7 ± 6.1, for the pretreatment and post-treatment dental casts respectively. The mean percentage improvement was 68.9%. The mean treatment duration was 3.0 ± 1.4 years. 42.6% of the sample was greatly improved, 49.1% was improved and 8.3% was not improved or became worse. The improvement of the PAR score at the post-treatment stage was explainable to some extent by the treatment period: the more recent was the period the better was the quality.

5.2 Introduction

Orthodontists and health care providers show increased interest into the efficiency of orthodontic treatment for correction of malocclusions. It is difficult, however, to assess treatment outcome in terms of objective measurements. Several indices have been developed to assess treatment success (Eismann, 1974; Gottlieb, 1975; Berg and Fredlund, 1981; Richmond *et al.*, 1992a). One of the earliest studies was performed by Myrberg and Thilander (1973). They examined 1486 treated cases and graded the treatment results according to a five-grade scale: good, acceptable, less good, poor, and no effect. Good results were obtained in 54% of the cases. The Occlusal Index (Summers, 1971) which was initially designed for other tasks, has been used too to evaluate the success of treatment (Pickering and Vig, 1976; Elderton and Clark, 1983; Shaw *et al.*, 1991). Other methods are the Six Keys to Optimal Occlusion (Andrews, 1972) and the Peer Assessment Rating Index (PAR-Index) which has been developed lately (Richmond *et al.*, 1992b). The aim of many of these indices is to assess malocclusion in a large sample. They apply a score to the dental and the occlusal features of a certain malocclusion and the sum of these scores ranks the malocclusion.

In recent years several studies have been conducted in which outcome of orthodontic treatment has been assessed with the PAR index, especially in the United Kingdom. In an investigation within the General Dental Service in England and Wales, the orthodontic treatment standards appeared to be poor (Richmond *et al.*, 1992c). A comparable study was done at 17 hospital-based orthodontic departments: the mean percentage change in the PAR score of all the departments was 67.6%. In this investigation 8 per cent of the patients were allocated to "the worse or no different" group (O'Brien *et al.*, 1993). A higher overall chance of a beneficial outcome in the Hospital Orthodontic Service than in general dental service was also the conclusion of an earlier pilot study. The majority of the cases in this study were showing a substantial improvement after treatment. Only 4 patients out of the 100 patients were allocated to the "worse or no different" group (Shaw *et al.*, 1991). O'Brien *et al.* (1993) showed that the treatment outcome was influenced by the grade of

the operator, the choice of treatment methods and by the departmental attitudes and aspirations. Also a correlation was found between the PAR Index and the Index of Orthodontic Treatment Need (IOTN), the risk of getting an "unimproved or made worse" treatment was especially high for cases of borderline need (Shaw *et al.*, 1991). In a study that was performed in Norway, where nearly all orthodontic treatment was done by specialists, the standard of orthodontic treatment outcome was better than in the United Kingdom. The mean percentage reduction in PAR score was 78 per cent and only 4 per cent of cases were categorized as "worse or no different" (Richmond and Andrews, 1993).

Recently the PAR index was introduced to the United States. Since then several studies were done using the PAR index. Feghali *et al.* (1995) assessed a sample of 100 most recent consecutively debonded orthodontic cases at the Case Western Reserve University (Ohio, USA) using the PAR index. The median pretreatment age was 13 years and median treatment duration was 32.7 months. The averages for pre- and post-treatment PAR scores were 34 $\pm$ 10 and 11 $\pm$ 5.6 respectively. The results demonstrated that 55% of the patients were "greatly improved", 41% "improved" and only 4% of the cases were defined as "no improvement". Also, at the same dental school, another study showed that the quality of orthodontic care delivered at CWRU has remained stable comparing cases debonded between 1993 and 1994 to those debonded between 1980 and 1985 (Feghali *et al.*, 1996; Hassanein *et al.*, 1996). Another comparative study was done between the graduate orthodontic clinics in Pittsburgh and Columbus, comparing the orthodontic treatment efficiency before and after the year 1984. The duration of treatment and the mean monthly rate of relative improvement in the PAR scores was assessed. Treatment efficiency in both programs increased as measured by decreased treatment duration between the pre- and post 1984 epochs. The mean monthly rates of reduction in the relative PAR score did not change (Rinaldi *et al.*, 1996).

The aim of the present study was to evaluate the overall quality of orthodontic treatment and treatment duration over a long time span in a large university clinic sample.

5.3 Material and methods

5.3.1 Material

The archives of the Department of Orthodontics and Oral Biology, University of Nijmegen (The Netherlands), contain records of 2368 patients. Only the cases which had both pretreatment and post-treatment dental casts were included in this study. Standard orthodontic study models of 1870 patients (799 male and 1071 females) were evaluated at the pretreatment and post-treatment stage. The mean age at the pretreatment stage was 13 $\pm$ 4.1 years and at the post-treatment stage 16 $\pm$ 3.9 years. The patients were categorized according to the year in which they finished active orthodontic treatment. Six post-treatment periods were distinguished: 1965-1970 (n = 51); 1971-1975 (n = 140); 1976-1980 (n = 238); 1981-1985 (n = 460); 1986-1990 (n = 559); and 1991-1995 (n = 422).

5.3.2 Methods

The PAR index (Richmond *et al.*, 1992a) was used to score pretreatment and post-treatment dental casts of the same patient. The index has seven components: upper anterior segment, lower anterior segment, left buccal occlusion, right buccal occlusion, overjet, overbite, centreline. The individual scores for the various components are finally weighted according to the British weighting factors and summed to the so called weighted PAR score, to be called PAR in this paper. A PAR of zero indicates good alignment and higher scores (rarely beyond fifty) indicate high levels of irregularity. The change in the total PAR reflects the degree of improvement and the success of orthodontic treatment. A malocclusion is defined as "greatly improved" when the post-treatment PAR is at least 22 points lower than the pretreatment PAR. The malocclusion is defined as "improved" when the post-treatment PAR is 30% lower than the pretreatment PAR, and cases showing a drop in the PAR of less than 30% are defined as "not improved" (Richmond *et al.*, 1992b).

Three examiners were incorporated in this study who were calibrated in the use of the PAR. To determine the measurement error and to assess the

intra- and inter-observer agreement, the PAR of a random sample of dental casts of 18 patients was evaluated by the three observers. For each patient two different dental casts (the first at the pretreatment stage and the second at the 5 years postretention stage) were measured twice. The time interval between the two measurements was at least 3 months.

5.3.3 Statistics

The magnitude of the intra- and inter observer duplicate error in the PAR was calculated. Systematical differences between observers were tested by the paired t-test. The inter- and intra-observer reliability was expressed as the Pearson's correlation coefficients between duplicate measurements.

To assess possible selectivity in missing records, patients who did (n = 1870) or did not have post-treatment records (n = 498) were compared on pretreatment characteristics using the t-test. Mean and standard deviation of the PAR were calculated at the pretreatment stage and at the end of active treatment. The percentage reduction in the PAR was calculated to assess the improvement. Cases who changed from a very low initial PAR at the pretreatment stage to a higher PAR with deterioration < -100% cause a negative skewness in the relative improvement distribution. To overcome this problem the PAR improvement was divided by the maximum PAR value. This will only affect the negative improvements. The mean percentage improvement was not affected, it changed from 67.7% to 68.9%. Analysis of variance and t-test were applied to compare the quality of treatment (PAR) for treatment period and gender respectively. Multiple regression analysis was performed to correct for possible confounders.

5.4 Results

5.4.1 Reproducibility

No significant systematical differences were found between the observers (paired t-test). The reproducibility of the PAR index is presented in Table 5-1, indicating a high level of reproducibility.

Table 5-1: *Intra- and inter-observer error and reliability of the assessment of the PAR index.*

type of agreement	error (points) (n = 108)	measurement / remeasurement correlation pretreatment (n = 18)	post-treatment (n = 18)
PAR-intra	0.85	0.98 -0.99	0.98 -0.99
PAR-inter	1.94	0.92 -0.99	0.96 -0.98

5.4.2 Missing records

Comparison of the sample of this study with the sample which contains all cases (t-test), showed that both groups were comparable with respect to gender, mean initial age, mean initial PAR and Angle classification.

5.4.3 Analysis of pre- and post-treatment PAR

Significant differences between males and females were found for the mean PAR at the pretreatment and at the post-treatment stage, the scores being higher in males. The mean treatment duration was 3.0 ± 1.4 years, being longer in males than in females. The mean PAR for the whole sample was initially 27.6 ± 10.0, and dropped to 7.7 ± 6.1 at post-treatment. The mean percentage improvement was 68.9% (Table 5-2). Of the total sample 42.6% was greatly improved, 49.1% was improved and 8.3% was not improved or became worse. Males were categorized more often as "greatly improved" (44.3%) and as "not improved" (9%), than females (Table 5-3).

There were significant differences in the quality of treatment over time (Table 5-4). The percentage change in the PAR varied from 65.0% (sd 28.8%) to 76.1% (sd 23.0%) between the different time periods. This change in PAR over time remained after correction for confounders (sex, Angle classification, initial age, initial PAR). An uncorrected decrease in post-treatment PAR of 0.75 per decade and after correction for confounders 0.62 per decade remained, indicating that the quality of orthodontic treatment increased over time. The treatment duration varied from 2.8 (sd 1.4) to 3.2 (sd 1.4) years between the different time periods, which was significantly

different too.

Table 5-5 shows the percentage of perfect scores (score = 0) of the different components of the PAR index. In only 4% of the cases a perfect lateral occlusion was reached at the end of active treatment. On the other hand a perfect centreline and alignment of the upper and lower front teeth was found in more than 80% of the cases.

Table 5-2: *Comparison of the mean weighted PAR score at the pretreatment stage (PARpre), at the post-treatment stage (PARpost), relative improvement in the PAR score, and the treatment duration for the whole sample and for male and female separately.*

	n	PARpre mean sd	PARpost mean sd	% change mean sd	duration mean sd
♂,♀	1870	27.6 ± 10	7.7 ± 6.1	68.9 ± 26.1	3.0 ± 1.4
♂	799	28.4 ± 10.2	8.2 ± 6.5	68.2 ± 26.3	3.2 ± 1.5
♀	1071	27.0 ± 9.8	7.4 ± 5.7	69.4 ± 25.9	2.9 ± 1.3
P value		0.002	0.006	0.019	<0.001

P value = t-test

5.5 Discussion

Nowadays the interest for quality control of orthodontic treatment is increasing. The PAR index (Richmond *et al.*, 1992a) was developed both as a self evaluation instrument for the practitioner to measure his own performance and as a measuring rod to assess overall quality in larger samples. The evaluation of large samples such as in the present study provides more insight into the level of final treatment outcome that can be obtained. This can attribute to the development of standards for quality control in orthodontics.

In the present study the overall pretreatment PAR was 27.6 ± 10 and

the post-treatment PAR was 7.7 ± 6.1, but there were significant differences between the treatment periods. The improvement of the PAR at the post-treatment stage can be explained to some extent by the treatment period: more recent periods produced better quality. For an institution as well as for a private office such an analysis can contribute to the discussion of orthodontic treatment over the years. As such it is an important tool in the process of total quality management in that specific clinic.

Table 5-3: *Classification of improvement for the whole sample and for male and female separately. For each category number and (percentage) are given.*

	Greatly improved	Improved	Not improved
♂,♀	796 (42.6%)	922 (49.1%)	152 (8.3%)
♂	354 (44.3%)	373 (46.7%)	72 (9.0%)
♀	442 (41.3%)	549 (51.3%)	80 (7.5%)

Greatly improved = more than 22 points reduction
Improved = more than 30% improvement
Not improved = less than 30% improvement

The sample of the present study was comparable to that at the Case Western Reserve University (Ohio, USA) where the mean PAR was 34 ± 10 at the pretreatment stage and 11 ± 5.6 at the post-treatment stage (Feghali *et al.*, 1995). Comparing these results it can be seen that in our study the finishing of treatment was better, but the percentage of cases in "the worse / no different" group was higher, being 8.3%. The low percentage (4%) of cases which were categorized as worse / no different (less than 30% improvement) in the study of Feghali *et al.* (1995) can be explained by the fact that the pretreatment score in Ohio was higher while the sample size was much smaller (n = 100). The higher the PAR at the pretreatment stage the higher the chance to achieve more than 30% reduction (Shaw *et al.*, 1991; O'Brien *et al.*, 1995).

Our finding regarding the mean percentage change in the PAR (68.9%) compares very well with the finding of O'Brien *et al.* (1993) in their investigation at 17 hospital-based orthodontic departments, being 67.6%. This comparability in the mean percentage change may be due to the similarity in the operators level - a mixture of senior and junior staff - in both studies. A higher percentage change (78%) was found in a Norwegian pilot sample (n = 220), but there the orthodontic treatment was performed by specialists only (Richmond and Andrews, 1993).

Table 5-4: *Comparison of the mean PAR at the pretreatment stage (PARpre), at the post-treatment stage (PARpost), relative improvement in the PAR, and the treatment duration for the whole sample according to treatment period.*

years	n	PARpre	PARpost	% change	duration
		mean sd	mean sd	mean sd	mean sd
65-70	51	29.5 ± 11.5	6.3 ± 6.5	76.1 ± 23.0	2.8 ± 1.4
71-75	140	28.6 ± 9.6	8.2 ± 6.9	68.4 ± 27.8	3.1 ± 1.6
76-80	238	29.1 ± 10.3	9.3 ± 7.6	65.0 ± 28.8	2.8 ± 1.4
81-85	460	27.8 ± 10.4	8.1 ± 5.6	67.4 ± 25.5	3.1 ± 1.5
86-90	559	27.0 ± 9.6	7.1 ± 5.5	70.5 ± 24.7	2.9 ± 1.4
91-95	422	26.7 ± 9.7	7.2 ± 5.7	70.0 ± 26.4	3.2 ± 1.4
P value		0.018	0.000	0.019	0.002

P value = One way ANOVA

In our study there were significant differences between males and females in the percentage change of the PAR and in the treatment duration. However, the differences were very small and not clinically relevant. The mean treatment duration in our study (3.0 ± 1.4 years) was comparable to the treatment duration in the orthodontic clinic at Case Western Reserve University (2.8 ± 1.6 years) and at the University of Southern California (2.9 ± 1.2 years) (Feghali *et al.*, 1997). It is remarkably, however, that

treatment time did not diminish although orthodontic techniques, especially fixed appliance techniques, evolved during the years.

Table 5-5: *Percentage of perfect scores (score = 0) at the post-treatment stage of the different components of the PAR index in 1870 patients.*

Component	Percentage score = 0	se
maxillary front	83	0.9
mandibular front	86	0.9
right and left occlusion	4	0.4
overjet / anterior crossbite	62	1.1
overbite / open bite	54	1.2
centreline	88	0.9

The individual scores for the different occlusal traits show that a high percentage of cases has a perfect centreline and perfect alignment of the front teeth after treatment. It seems to be much more difficult to reach a perfect lateral occlusion, overbite and overjet. In only 4% of the patients it was possible to achieve a perfect lateral occlusion at the post-treatment stage. This may be due to the fact that the score for the lateral occlusion is very sensitive to deviations from the norm: a very minor deviation from full interdigitation is already scored as a non-optimal occlusion. Furthermore, the recording zone for the buccal occlusion extends from the canine to the last molar, either first, second or third, even if the second and third molar were not involved in the treatment due to their late eruption. These factors definitely will affect the final PAR score and with that the categorization into the three grades (greatly improved, improved, worse / no different), especially in cases with a minor initial PAR score. To improve the validity of the PAR for this recording it should be considered to exclude the second and third molars from the recording and to allow for a certain (predefined) degree of deviation from full interdigitation. For example, score 1 should be given to the sagittal buccal occlusion, only when two or more teeth have 0 to ¼ premolar width

deviation from full interdigitation. A perfect vertical relationship was achieved in only 54% of the patients. This may give an indication for the difficulty in treating overbite and open bite at least in our sample. The results for the overjet were slightly better.

The British weighting factors for overjet, overbite, lateral occlusion and centreline are 6, 2, 1 and 4 respectively (Richmond *et al.*, 1992a), while the American weighting factors for the overjet, overbite, lateral occlusion and centreline are 5, 3, 2 and 3 respectively (Deguzman *et al.*, 1995). These differences in weighting may be due to the difference in the design of the two studies which determined the validity of the PAR index. In the British validation study 74 dentists participated, representing the various groups carrying out orthodontic treatment in England and Wales: 48 possessing specialist orthodontic qualifications and 26 without orthodontic qualifications. On the other hand, in the American validation study only 11 dentists all with specialist orthodontic qualifications were involved. So, it is recommended to validate the PAR index according to the orthodontic standard of the country involved, taking into account all panels concerned with orthodontic treatment i.e. orthodontists and general practitioners.

5.6 Conclusion

In this large university sample a percentage change in the PAR score of 68.9% could be reached, while it appeared that the quality of the orthodontic treatment was improving over the years. Validation of the PAR index according to the Dutch orthodontic standard is recommended.

5.7 Literature

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Chapter 6

Stability of orthodontic treatment outcome: follow-up until 20 years postretention

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6.1 Abstract

Dental casts of 2368 patients were evaluated for the long term treatment outcome using the Peer Assessment Rating (PAR) index. The PAR index was measured at the pretreatment stage, directly post-treatment, postretention, 2 years postretention, 5 years postretention and then every 5 years until 20 years postretention. The mean absolute change as well as the percentual change per year (relapse) related to the postretention stage was calculated. ANOVA was applied to compare the mean change in the PAR between cases with and without a fixed retainer at the postretention stage and up to 10 years postretention.

The results indicate that 64% of the achieved orthodontic treatment result was maintained 20 years post-treatment. In the first two years after retention 19.2% per year of the orthodontic treatment relapse as measured with the PAR index takes place. Cases which finished the retention period earlier than 15 (female) or 16 (male) years of age showed more relapse. All occlusal traits relapsed gradually over time but remained stable at later stages with the exception of the lower anterior contact point displacement which showed a fast and continuous increase, even exceeding the initial score. It should be more commonly considered to maintain retainers if some growth is still expected. Also, all patients should be informed prior to treatment about treatment limitations in order to better meet their expectations.

6.2 Introduction

Evaluation of treatment results and long term post-treatment assessment of orthodontically treated malocclusions has been of interest for several decades (King, 1974; Little *et al.*, 1988; Fidler *et al.*, 1995). Follow-up studies of treated cases have shown that although improvement in the dentition can obviously be achieved, there is a tendency to return towards the original malocclusion many years post-treatment (Owman *et al.*, 1989; Rossouw *et al.*, 1993; Harris and Vaden, 1994; De la Cruz *et al.*, 1995; Elms *et al.*, 1996a, 1996b). It is obvious that there is a large variability in orthodontic treatment outcome for different individuals. This variability may be due to treatment approach, patient cooperation, growth and adaptability of the hard and soft tissues. Additional factors that may influence the stability of orthodontic treatment are the type, duration and the timing of the retention appliance (Nanda and Nanda, 1992).

Most studies are concerned with the description of long-term stability of specific treatment regimes for specific types of malocclusion such as the Angle Class II/1 (Ahlgren, 1993; Ghafari *et al.*, 1994; Hansen *et al.*, 1995; Otuyemi and Jones, 1995; Elms *et al.*, 1996a). Other studies evaluated the stability of orthodontic treatment outcome longitudinally for specific occlusal traits such as open bite, overbite, overjet, posterior crossbite, intercanine and intermolar distance, and lower anterior crowding (Ghafari *et al.*, 1994; Hansen *et al.*, 1995; Brin *et al.*, 1996; Dellinger, 1996).

In recent years the PAR index was developed to assess treatment outcome in a quantitative manner (O'Brien *et al.*, 1993). The PAR index offers uniformity, objectivity and standardisation in assessing the outcome of orthodontic treatment. Also the index is amenable to statistical analysis and easy to apply (Richmond *et al.*, 1992a, 1992b; Buchanan *et al.*, 1993; O'Brien *et al.*, 1993).

In the literature, only two studies were found that assessed the long-term stability of orthodontic treatment in a quantitative manner utilising the PAR index (Fox and Chadwick, 1994; Otuyemi and Jones, 1995). Fox and Chadwick (1994) found a PAR reduction of 72% (from 29.5 to 8.3) in 100

cases at post-treatment. This reduction relapsed to 57% (12.8, n = 51) at one year postretention. Otuyemi and Jones (1995), evaluated 50 Class II/1 malocclusions. The results indicated a PAR reduction of 82%. Maintenance of post-treatment results at 1 and 10 years postretention was only achieved in 60 and 38 per cent of the cases, respectively. The major factor involved in this deterioration appeared to be late lower anterior crowding.

Kahl-Nieke *et al.* (1996) emphasised that 'the review of the literature points out the need for a quantitative and qualitative assessment of post-treatment changes by using a sample that is large enough for statistical analysis consisting of cases out of retention for at least 10 years'. At the University of Nijmegen, The Netherlands, such a large treated sample is available (more than 2000 cases). The aim of this study was to evaluate the long-term post-treatment results until 20 years postretention utilising the PAR index.

6.3 Material and methods

6.3.1 Subjects

The archives of the Department of Orthodontics and Oral Biology, University of Nijmegen, contain records of 2368 patients available for follow-up study. Only the cases which had at least a pretreatment and post-treatment or post-retention dental cast were included in this study. Patients with damaged dental casts or with prosthetic replacements that would affect the orthodontic outcome were excluded. Dental casts were routinely made at the following stages: pretreatment (TP); post-treatment (T00); postretention (T0) which means cessation of all removable retainers, bonded retainer wires may be maintained; 2 years after T0 (T2); 5 years after T0 (T5) and then every 5 years until 20 years after T0 (T20). Table 5-1 shows the number of patients, the sex distribution and the mean age (± sd) at all stages. The decrease in the number of patients available for analysis at the later stages is partly due to drop-out and also due to the fact that more recent post-treatment patients have not yet reached advanced postretention stages. More insight into the

drop-out of the study was obtained for the large cohort that could be followed up to 5 years postretention. This cohort has an initial number of 1705 patients and ends up with 1167 patients, which means a drop-out of 32%.

Table 6-1: *Number of patients, sex distribution and mean age (± sd) at all observational stages.*

	number			mean	
stages	total	male	female	age	sd
TP	2368	1025	1343	12.8	± 4.0
T00	1870	799	1071	16.0	± 3.9
T0	2028	884	1144	16.9	± 3.5
T2	1440	633	807	18.7	± 3.4
T5	1167	517	650	21.8	± 3.4
T10	576	241	335	26.3	± 2.9
T15	226	94	132	31.4	± 3.0
T20	82	37	45	36.6	± 2.4

TP = pretreatment; T00 = post-treatment; T0 = postretention; T2 = 2 years postretention; T5 = 5 years postretention; T10 = 10 years postretention; T15 = 15 years postretention; T20 = 20 years postretention.

A subdivision was made between patients with and without a fixed retainer. Patients were divided into two groups: cases with (n = 585) and without (n = 945) fixed retainer. The number of patients who could have a fixed retainer beyond 10 years postretention was too small for analysis. Therefore the analysis of the fixed retainer was restricted to 10 years postretention (T10). In comparing relapse in patients with and without a retainer, the phenomenon of "confounding by indication" may play a role. Possible confounders such as the initial PAR and PAR subscores were taken into consideration.

6.3.2 Methods

The PAR index (Richmond *et al.*, 1992a, 1992b) was used to score pretreatment, post-treatment and all available postretention dental casts of the same patient. The index has seven components: upper contact point displacement, lower contact point displacement, left buccal occlusion, right buccal occlusion, overjet, overbite and centreline. The individual scores for the various components are finally summed up for the so called weighted PAR score, to be called "PAR" in this paper. A PAR of zero indicates good alignment; higher scores (rarely beyond fifty) indicate the level of irregularity. The change in the PAR reflects the degree of improvement and the success of orthodontic treatment. In this study, the components of the PAR were re-categorized by joining the left and right buccal occlusion into one subcomponent, named lateral occlusion. The overjet component was split up into two subcomponents, overjet and anterior crossbite. The overbite component was split up into two subcomponents, the overbite and the open bite, thus resulting in the following 8 subcomponents: upper contact point displacement, lower contact point displacement, lateral occlusion, overjet, anterior crossbite, overbite, open bite and centreline. All subcomponents were weighted according to the British weighting factors (Richmond *et al.*, 1992a).

Three examiners were incorporated in this study. To determine the measurement error in the PAR and to assess the intra- and inter-observer agreement, a random sample of dental casts of 18 patients was evaluated by the three observers. For each patient the dental casts at TP and at T5 were measured twice. The time interval between two intra-observer measurements was at least three months.

6.3.3 Statistics

Systematical differences between observers were tested by the paired t-test. Inter- and intra-observer reliability was expressed as Pearson's correlation coefficients between re-measurements. The magnitude of the intra- and inter-observers duplicate error in the PAR was calculated.

The drop-out analysis includes the t-test to compare drop-outs with the

remaining patients for sex, Angle classification and PAR at TP, T00, T0, and T2.

For all stages, the mean and standard deviations of the PAR were calculated as well as the absolute and percentual changes. The t-test was used to compare the mean changes in PAR between the postretention stages, between patients who finished active treatment before 15 (female) or 16 (male) years of age, and patients who finished treatment at an older age.

The mean percentage change per year (relapse) related to T0 was calculated. Differences between the mean PAR subscores for the cases with and without fixed retainers were tested with the t-test at TP. Analysis of covariance (correcting for the confounders) was applied to compare the mean change in the PAR between cases with and without fixed retainers at T0 up to T10.

6.4 Results

6.4.1 Reproducibility

No significant systematical differences were found between examiners (paired t-test). The measurement errors were 0.9 and 1.9 PAR points for the intra- and the inter-observer measurements respectively. The intra-observer correlation ranged over the two periods from 0.98 to 0.99 and the inter-observer correlation from 0.92 to 0.99, indicating a high level of reliability.

6.4.2 Drop-out analysis

No significant differences were found between the drop-out and remaining patients for sex, Angle classification, initial PAR and post-treatment PAR. The mean PAR of the drop-out patients (8.2 $\pm$ 6.1) at postretention was significantly lower than the PAR of the remaining patients (9.0 $\pm$ 7.0). Also the mean PAR at 2 years postretention was significantly lower in the drop-out patients (9.6 $\pm$ 7.1) compared to the remaining patients (11.7 $\pm$ 8.2).

6.4.3 PAR and follow-up stages

Table 6-2 shows the mean and standard deviations for the PAR at the pretreatment stage and the means and standard deviations as well as the absolute and percentual change with respect to TP. The mean PAR at the pretreatment stage was 27.2 ± 10 and at the post-treatment stage 7.7 ± 6.1. During the postretention period until 20 years postretention the mean PAR score increased gradually to 14.8 ± 8.3.

Table 6-2: *Mean PAR and mean absolute and percentual change at all observational stages with respect to pretreatment (TP). For explanation of stages see Table 6-1.*

stages	n	mean PAR	mean absolute change	mean change in %
TP	2368	27.2 ± 10.0		
T00	1870	7.7 ± 6.1	19.9 ± 10.9	69 ± 26
T0	2028	8.4 ± 6.6	18.9 ± 10.9	66 ± 28
T2	1440	11.0 ± 7.8	16.5 ± 11.1	57 ± 31
T5	1167	12.8 ± 8.7	15.0 ± 11.4	51 ± 33
T10	576	14.5 ± 9.7	13.7 ± 12.0	46 ± 36
T15	226	14.9 ± 9.6	14.5 ± 11.3	47 ± 33
T20	82	14.8 ± 8.3	12.7 ± 11.9	40 ± 40

The mean percentage change compared to TP was 69 ± 26 at the post-treatment stage and 40 ± 40 at 20 years postretention. The highest post-treatment mean percentage change per year (relapse) was found during the first 2 years postretention, being 19.2% per year of the total relapse. From T5 on, minimal changes were observed (Table 6-3).

6.4.4 PAR and age

There was a highly significant difference (P value < 0.001) in the PAR change between T0 and T2 when comparing cases which finished active treatment before 15 (female) or 16 (male) years of age to those who finished

treatment at an older age. The mean change in the PAR was 3.1 ± 5.6 and 1.9 ± 4.8 for the cases which finished treatment early and late, respectively.

6.4.5 PAR subscores

Figures 6-1a and 6-1b show the mean PAR for the different PAR subscores per stage. It shows an immediate decrease in all PAR subscores due to treatment except for the anterior open bite where the mean post-treatment score was higher than the pretreatment score. The score for the lower anterior contact point displacement shows the largest changes after treatment. The score was deteriorating up to 20 years postretention. The score at T20 (2.9 ± 3.3) was even higher than at the start of treatment (2.2 ± 3.1).

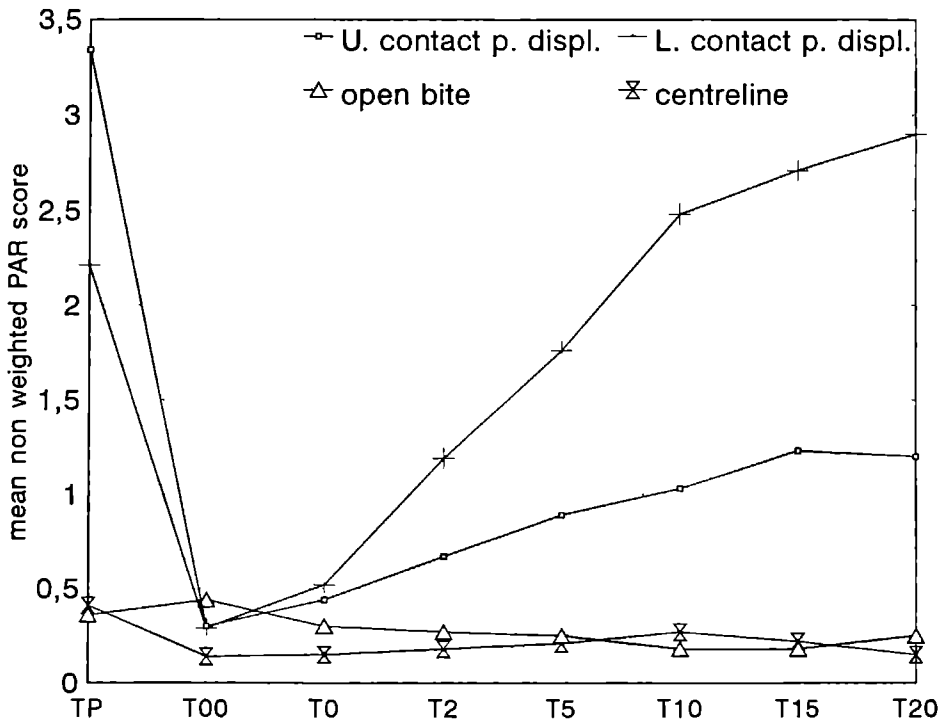

Figure 6-1a: *Mean non-weighted PAR subscores at the pretreatment stage (TP), post-treatment (T00), postretention (T0), and up to 20 years postretention (T20).*

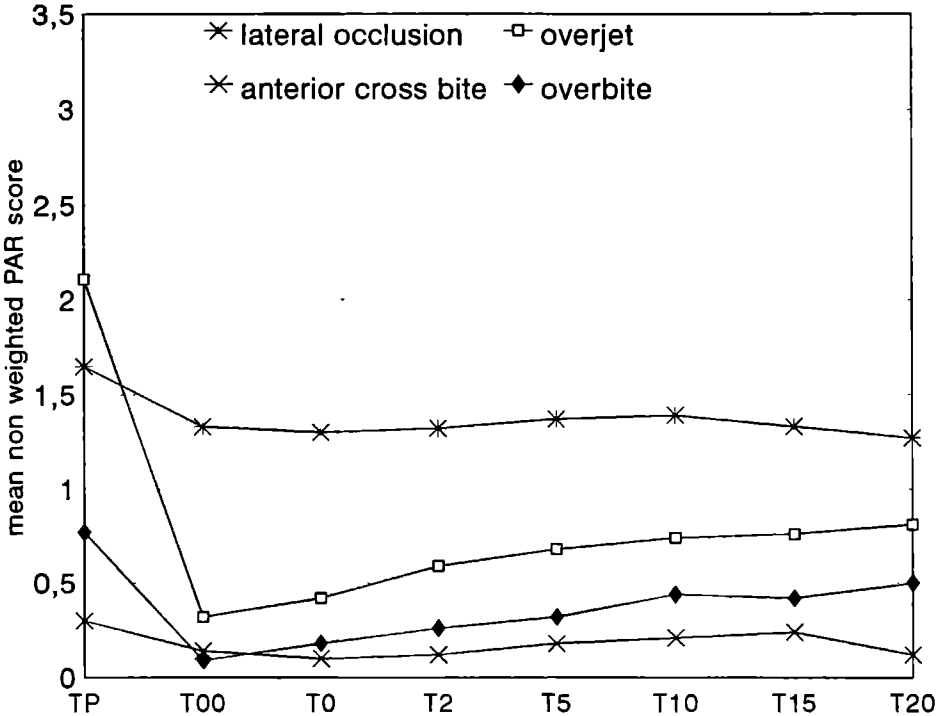

Figure 6-1b: *Mean non-weighted PAR subscores at the pretreatment stage (TP), post-treatment (T00), postretention (T0), and up to 20 years postretention (T20).*

6.4.6 PAR and retention type

Pre-analysis showed that "confounding by indication" has to be corrected by the initial PAR and the initial subscores "upper and lower contact point displacement" and "overbite" as confounders. Figure 6-2 shows the mean PAR for the cases with and without fixed retainer at TP, T00 and T0 up to T10. The pretreatment PAR was significantly higher (P value < 0.001) in the cases with a fixed retainer (28.5 ± 9.9) compared to those without a fixed retainer (26.6 ± 10.1). This significant difference was reversed at T00 and the same relation was kept up to T10.

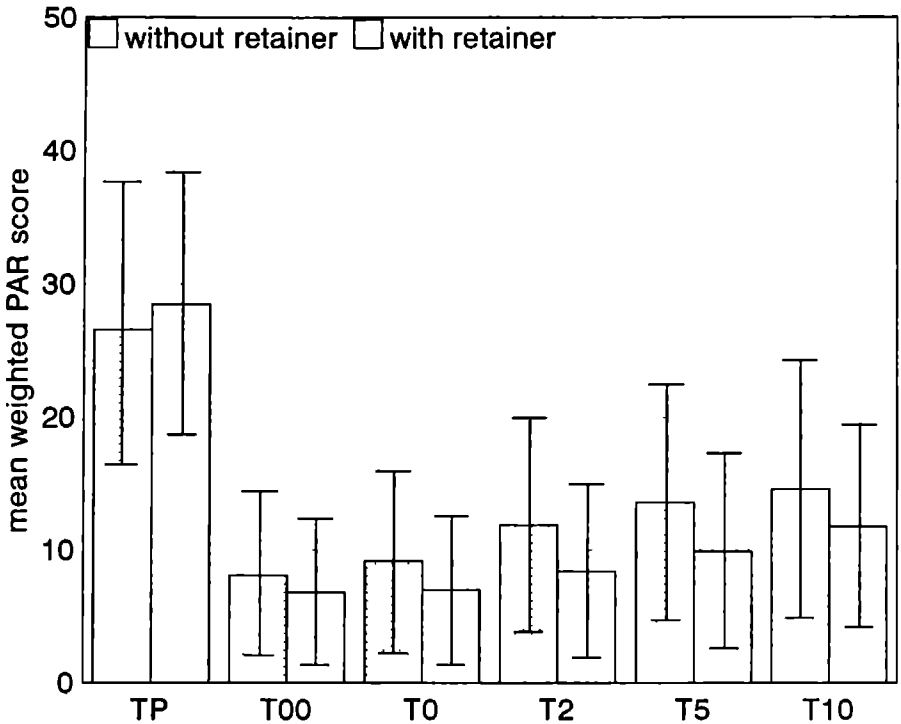

Figure 6-2: *Mean PAR for the cases with and without fixed retainer separately at the pretreatment (TP), post-treatment (T00), postretention (T0), and up to 10 years postretention (T10).*

Comparison of the mean change of the PAR after correction for confounders for cases with and without fixed retainer only showed a significant difference between T0 and T2 (Table 6-4).

6.5 Discussion

This study was designed as a longitudinal retrospective study. Generally speaking, it is very difficult to control for selectivity of cases due to drop-out in such a design. Indeed, a difference between drop-out patients and

remaining patients after 5 years was found. The drop-out had lower PAR values indicating that successfully treated patients tended to drop-out, but the difference (2 PAR points) is not clinically relevant and selectivity in drop-out may be neglected.

In this study the PAR index was used as a measurement for orthodontic treatment outcome. This index has certain limitations as it measures only occlusal changes which, although important, are not the only factors in orthodontic treatment. Factors like decalcification, root resorption, gingival recession, inclination of the incisors, and facial aesthetics undoubtedly contribute to the quality of treatment.

Table 6-3: *Mean relapse in PAR between consecutive stages. Mean percentual change is relative to the total relapse over 20 years (6.08) the retention period (T00 - T0) is commonly 1 year. For explanation of stages see Table 6-1.*

periods	n	mean age at start of interval	mean absolute change	mean % change	mean % change/ year
T00-T0	1530	15.7 ± 3.1	0.46 ± 5.5	7.6	7.6
T0-T2	1351	16.6 ± 3.3	2.34 ± 5.2	38.5	19.2
T2-T5	921	18.6 ± 3.3	1.47 ± 4.2	24.2	8.1
T5-T10	506	21.3 ± 2.9	0.71 ± 4.0	11.7	2.3
T10-T15	186	26.4 ± 2.7	0.44 ± 4.0	7.2	1.5
T15-T20	59	32.2 ± 2.5	0.66 ± 3.2	10.8	2.1

In this study the mean reduction in the PAR at the end of active treatment was 19.9 ± 10.9. The reduction was still 14.5 ± 11.3 and 12.7 ± 11.9 at 15 and 20 years postretention respectively. This indicates that 64% of the achieved orthodontic treatment results as measured by the PAR index still existed 20 years postretention. On the other hand, only a 40% reduction of the PAR compared to the pretreatment PAR existed. When considering these figures, it should be taken into account, however, that the time span is 20

years. This means that the measured PAR at 20 years postretention is not the resultant of orthodontic treatment alone but also of physiological and/or pathological changes in the dentition and surrounding tissues during those years.

The achieved results started to relapse even within the retention period, although this change (0.46 ± 5.5 PAR points) is not clinically relevant. Most of the relapse (38.5%) occurs in the first 2 years postretention with a mean percentage change of 19.2% per year. The mean age was at the post-treatment stage 15.7 ± 3.1 and at the postretention stage 16.6 ± 3.3. This indicates that there were cases reaching the postretention stage while some potential growth was still present. This remnant of growth may influence the stability of the result of the orthodontic treatment (Nanda and Nanda, 1992). Comparing the mean changes in the PAR between postretention periods distinguishing between cases which finished the retention period earlier or later than 15 (female) and 16 (male) years of age, the only significant difference was found within the first 2 years after retention.

Table 6-4: *Comparison of mean absolute change of the PAR for cases in which a fixed retainer was used to those without fixed retainer, tested by analysis of covariance correcting for upper and lower contact point displacement, overbite and the PAR at pretreatment stage. For explanation of the stages see Table 6-1.*

periods	with fixed retention		without fixed retention			
	n	mean change	n	mean change	sd*	P value
T00-T0	585	0.10	945	0.68	5.5	0.056
T0-T2	335	1.21	1016	2.71	5.1	< 0.001
T2-T5	129	1.39	792	1.48	4.2	0.82
T5-T10	13	-0.9	493	0.75	3.9	0.14

sd* = residual sd of analysis of covariance
P value = analysis of covariance

The changes were larger in the cases which finished the retention period at a younger ages. Similar results were found by comparing the mean changes in the PAR between cases with and without fixed retainer. A significant difference was found within the first 2 years after retention. The change was larger in the cases without fixed retainer. These results highlight the necessity to prolong the retention period until the end of the maturational status of growth.

As shown by the analysis of the sub-components of the PAR, all occlusal traits of the original malocclusion showed improvement due to treatment except the anterior open bite, which even increased during treatment. This may be due to treatment mechanics, as it self-corrects during the retention periods. All occlusal traits relapsed gradually over time, but remained stable at later stages with the exception of the lower anterior contact point displacement which showed a fast and continuous increase, even exceeding the initial score. This phenomenon, described as tertiary crowding, is well known from other clinical studies (Little *et al.*, 1988; Artun *et al.*, 1996).

To prevent anterior lower arch crowding, bonded retainers are commonly used. In our sample, 38% of the patients had such a retainer. When a bonded retainer was used, the mean change of the PAR 2 years post-retention was 1.2. Without a retainer this change was found to be significantly higher, i.e. 2.7. The cases with fixed retention show a consistently better alignment at the post-treatment stage and up to 10 years postretention, even while the PAR was higher at the pretreatment stage. These findings should be interpreted with caution, however, because of the possibility of "confounding by indication" at the pretreatment stage. It is common practice that the decision for retention is partly based on the pretreatment characteristics (Little *et al.*, 1988; Nanda and Nanda, 1992; Artun *et al.*, 1996). Comparison of the pretreatment subscores for the cases with and without fixed retention shows that the highest significant indicator for considering the case as a fixed retainer case later on is the severity of the upper and lower anterior crowding.

There is no scientific proof that fixed retainers have a harmful effect on

the hard and soft tissues adjacent to the wire. Artun (1984) concluded from his investigation that long term use of bonded retainers (1 to 8 years post orthodontic treatment) caused no damage to the teeth and to the hard and soft tissues adjacent to the wire. Despite this, the usage of a fixed retainer should be limited to cases with a doubtful prognosis of the orthodontic treatment stability and for those patients who worry about small changes in the orthodontic treatment results.

6.6 Conclusion

64% of the achieved orthodontic treatment result was maintained 20 years postretention. 19.2% per year of the orthodontic treatment relapse as measured with the PAR index takes place in the first 2 years after retention. In this period, patients who finished the retention period younger than 15 (female) or 16 (male) years of age relapse more. All occlusal traits relapsed gradually over time but remained stable at later stages with the exception of the lower anterior contact point displacement which showed a fast and continuous increase, even exceeding the initial score. It should be more commonly considered to maintain the retainers if there is some growth still expected. Also, all patients should be informed prior to treatment about treatment limitations in order to give them more realistic expectations.

6.7 Literature

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Chapter 7

Occlusal changes in Class I, Class II and Class III malocclusions: cases 5 years postretention

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7.1 Abstract

Dental casts of 2368 patients were available for follow-up study. Five sets of dental casts were used: Pretreatment (TP); post-treatment (T00); post-retention (T0), 2 years postretention (T2) and 5 years postretention (T5). The Peer Assessment Rating (PAR) index was used to score all available sets of dental casts for the same patient at TP up to T5.

One-way ANOVA was used to compare the treatment duration, the mean PAR, and the absolute and percentual change in the PAR for the different Angle Classes at all stages. The Scheffe test was used for multiple comparison.

The lowest PAR at the post-treatment stage was found for Class II/2 patients (6.2 $\pm$ 4.7), maintaining the lowest PAR until 5 years postretention. Class III malocclusions have the highest PAR at the pretreatment stage and at all other post-treatment stages. During the post-treatment stages the amount of relapse for the different Angle Classes was comparable.

7.2 Introduction

Every orthodontist, ideally, develops a treatment plan that will produce a harmonious dentition which will remain stable over the years. Most orthodontists would agree that stability is a good criterion for judging a successfully treated case. Reality, however, is that treated cases relapse after a certain period of time.

Various types of relapse and their causes have been discussed in the literature. Relapse can be due to skeletal and/or dental changes after treatment. Skeletal changes are often due to continuing growth after treatment with recurrence of the original growth pattern. The three most common types of dental relapse are re-crowding of the lower incisors, recurrence of the deep overbite, and spacing of the upper incisors (Riedel, 1960; Chateau and Démogé, 1961; Carriére, 1975; Fried, 1979; Shapiro and Kokich, 1981; Brid, 1983; Harris and Vaden, 1994; Dellinger, 1996; Elms *et al.*, 1996a).

Only a few long-term follow-up studies on dental casts are available providing an overall description of the changes that take place in the dentition after the cessation of orthodontic treatment (Gardner and Chaconas, 1976; Sadowsky and Sakols, 1982; Battagel, 1994). Long-term studies on occlusal changes during the post-treatment period mainly describe changes in specific occlusal traits such as intercanine width, overjet and overbite (Johanson, 1977; Ghafari *et al.*, 1994; Artun *et al.*, 1996).

The Class II/1 malocclusion is the malocclusion that is most commonly described from the post-treatment point of view (Fidler *et al.*, 1995; Elms *et al.*, 1996a; Elms *et al.*, 1996b). Battagel (1993a, 1994) and Battagel and Orton (1993b) published extensive studies on the stability of treated Class III malocclusions. Studies on treatment results in Class I cases are mainly dealing with upper and lower anterior alignment and changes in the arch form (Dela-Cruz *et al.*, 1995; Weinberg and Sadowsky, 1996).

Measuring treatment outcome requires an objective and reliable yardstick. The PAR index, developed by Richmond *et al.* (1992b) has been adopted as such a method by many researchers. Otuyemi and Jones (1995) evaluated treatment and long-term postretention results in 50 Class II/1

malocclusions with the PAR index. The results suggested a high treatment standard, as indicated by the mean percentage PAR score reduction (82.5%). However, the mean percentage change in the PAR score at 1 and 10 years postretention deteriorated to 69.9% and 48.6%, respectively. The major factor involved in this deterioration appeared to be late lower anterior crowding. In a previous study Al Yami *et al.* (1997) showed that the mean percentage change was 46% and 40% at 10 and 20 years postretention respectively. All occlusal traits relapsed gradually over time, but remained stable at later stages with the exception of the lower anterior contact point displacement which showed a fast and continuous deterioration, even exceeding the initial score. This study, however, did not answer the question whether different types of malocclusions show different relapse patterns over time. Therefore, the aim of this investigation was to compare treatment outcome for Angle Class I, II/1, II/2, and Class III malocclusions until five years postretention as measured by the PAR index.

7.3 Material and methods

7.3.1 Material

The archives of the Department of Orthodontics and Oral Biology, University of Nijmegen (The Netherlands), contain records of 2368 patients available for follow-up study. Five sets of dental casts were used: Pretreatment (TP); post-treatment (T00); postretention (T0), which means end of removable retention, fixed retainer may be maintained; 2 years postretention (T2) and 5 years postretention (T5) (Table 7-1). All available sets of dental casts from the pretreatment up to the 5 years postretention stage were included in this study. This means that all patients were measured at TP and all patient had at least one follow-up evaluation. Cases with damaged dental casts or with prosthetic replacements that would affect the final analysis were excluded. Table 7-2 shows the number of patients divided into groups according to the Angle classification at the pretreatment stage, the sex distribution and the mean age ($\pm$ sd). The decrease in number of patients available for analysis at the later

stages is partly due to drop-out and partly due to the fact that more recent post-treatment patients have not yet reached advanced postretention stages.

Table 7-1: *Definition of the times of measurement (stages).*

Time	Number	Definition of stages
TP	2368	pretreatment
T00	1870	end of active treatment
T0	2028	postretention: end of removable retention, fixed retainer may be maintained
T2	1440	2 years after T0 (2 years postretention)
T5	1167	5 years after T0 (5 years postretention)

More insight into the drop-out of the study was obtained for a large cohort that could be followed up to 5 years postretention. This cohort has an initial number of 1705 patients and ends up with 1167 patients, which means a drop-out of 32%.

7.3.2 Methods

The PAR index (Richmond *et al.*, 1992a) was used to score all available sets of dental casts for the same patient at TP and up to T5. The index has seven components: upper anterior segment, lower anterior segment, left buccal occlusion, right buccal occlusion, overjet, overbite, and centreline. All subcomponents were weighted according to the British weighting factors (Richmond *et al.*, 1992a). The individual scores for the various components are summed up for the so-called weighted PAR score, to be called PAR in this paper. A PAR of zero indicates good alignment and higher scores (rarely beyond fifty) indicate high levels of irregularity. The change in the total PAR reflects the degree of improvement and the success of orthodontic treatment. A malocclusion is defined as "greatly improved" when the post-treatment PAR is at least 22 points lower than the pretreatment PAR. The malocclusion is defined as "improved" when the post-treatment PAR is 30% lower than the pretreatment PAR, and cases showing a drop in the PAR of less than 30%

are defined as "not improved" (Richmond *et al.*, 1992b).

Three examiners were incorporated in this study. To determine the measurement error and to assess the intra- and inter-observer agreement, the PAR of a random sample of dental casts of 18 patients was evaluated by the three observers. For each patient two dental casts, one at TP and one at T5 were measured twice. The time interval between the two intra- observer measurements was at least 3 months.

7.3.3 Statistics

The magnitude of the intra- and inter-observers duplicate error in the PAR was calculated. Systematical differences between observers were tested by the paired t-test. The inter- and intra-observer reliability was expressed as the Pearson's correlation coefficients between duplicate measurements.

The drop-out analysis includes the t-test to compare the drop-out patients with the remaining ones for sex, Angle classification and PAR at TP, T0, T00, and T2.

One-way ANOVA was used to compare the different Angle Classes at all stages. The Scheffe test was used for multiple comparison. Correlation coefficients were calculated between treatment duration and pretreatment PAR scores. The classification of the cases into three improvement categories (i.e. "greatly improved", "improved", and "not improved or getting worse"), are described in relation to stages.

7.4 Results

7.4.1 Reproducibility

No significant systematical differences were found between examiners (paired t-test). The measurement errors were 0.9 and 1.9 PAR points for the intra- and the inter-observer measurement respectively. The intra-observer correlation ranged over the two periods from 0.98 to 0.99 and the inter-observer correlation from 0.92 to 0.99, indicating a high level of reliability.

7.4.2 Drop-out analysis

No significant differences were found between the drop-out patients and the remaining ones for sex, Angle classification, initial PAR and post-treatment PAR. The mean PAR of the drop-out patients (8.2 ± 6.1) at postretention was significantly lower than the PAR of the remaining patients (9.0 ± 7.0), also the mean PAR at 2 years postretention was significantly lower in the drop-out patients (9.6 ± 7.1) when compared to the remaining patients (11.7 ± 8.2).

7.4.3 Comparison of different types of malocclusion

A significant difference was found in the mean treatment duration (TP-T00) for the different types of malocclusion (Table 7-3). The Scheffe test indicates that the significant difference was between Class I (2.8 ± 1.5 years) and Class II/1 (3.1 ± 1.4 years).

Table 7-2: *Number of patients, the sex distribution and the mean age (± sd) divided according to the Angle classification at the pretreatment stage (TP).*

	Number						Age	
Angle	Total	%	♂	%	♀	%	mean	sd
Class I	564	(24)	259	(46)	305	(54)	13.8	± 5.2
Class II/1	1583	(67)	668	(42)	915	(58)	12.4	± 3.4
Class II/2	180	(7)	81	(45)	99	(55)	13.7	± 4.6
Class III	41	(2)	17	(41)	24	(59)	12.5	± 2.5
Total	2368	(100)	1025	(43)	1343	(57)	12.8	± 4.0

Comparison of the mean PAR for the different Angle Classes at the pretreatment stage (Table 7-4) indicates a highly significant difference. The highest PAR was found for Class III malocclusions (31.8 ± 12.4) and the

lowest for Class I malocclusions (24.3 ± 10.9). The lowest mean PAR at the post-treatment (T00) stage was for Class II/2 (6.2 ± 4.7), maintaining the lowest PAR until 5 years postretention. The highest mean PAR was found for Class III cases at all treatment stages. This pattern was confirmed by many significant differences using the Scheffe multiple comparison test.

Table 7-3: *Comparison of the treatment duration in years for the Angle Classes.*

	Treatment duration		
Angle	n	mean	± sd
Class I	459	2.8	± 1.5
Class II/1	1234	3.1	± 1.4
Class II/2	146	3.2	± 1.3
Class III	31	3.3	± 1.6
P value		< 0.001	

P value = One Way ANOVA

No significant correlation was found between the treatment duration and the PAR at the pretreatment stage (TP) neither for the whole sample, nor for the different types of malocclusion separately.

Comparison of the changes in the absolute PAR with respect to the PAR at the adjacent treatment stage (Table 7-5) indicates a highly significant difference between the Angle Classes only for the period TP-T00. The Scheffe test indicates that the significant difference was due to the difference between Class I (improvement = 17.3 ± 12) and Class II/1 (improvement = 20.9 ± 10.4) at the post-treatment stage.

Figure 7-1 shows the mean percentual reduction in the PAR for the different Angle Classes at the post-treatment stage (T00). The highest percentage reduction was found for Class II/2 (72.9 ± 22.3 per cent) and the lowest was for Class III (59.5 ± 34.4 per cent). The Scheffe test indicates

that the difference between Class I and Class II/1 and between Class I and Class II/2 was significant.

When classifying the improvement into three categories it was found that the treatment results tended to change over time from "greatly improved" to "not improved or getting worse" (Fig. 7-2).

7.5 Discussion

Fox (1993), Kerr *et al.* (1993) and O'Brien *et al.* (1993) have reported about outcome, directly after active orthodontic treatment. Such short term studies may provide the "golden standard" as was proposed by Tahir *et al.* (1997), being representative of "the best the profession has to offer" against which other samples could be compared. On the other hand long term evaluation of large samples such as in the present study provides more insight into the level of final treatment outcome that can be obtained. This is important to know for both the practitioner and patient, in order not to arouse unrealistic expectations of the possibilities of orthodontic treatment.

This study was designed as a longitudinal evaluation. Generally speaking, it is very difficult to control for selectivity of cases due to drop-out in such a design. Indeed, a difference between drop-out and remaining patients after 5 years was found. The drop-out had lower PAR values indicating that successfully treated patients tended to drop out, but the difference (2 PAR points) is not clinically relevant and selectivity in drop-out may be neglected.

In this study, the PAR index was utilized as a measurement for orthodontic treatment outcome. This index, however, has some limitations. It only measures tooth position which, although important, is not the only factor in orthodontic treatment. Factors like incisor inclination, decalcification, root resorption, gingival recession, and facial aesthetics undoubtedly contribute to the quality of treatment.

The mean absolute improvement in the PAR directly after treatment varied from 17.3 $\pm$ 12.0 for Class I cases to 20.9 $\pm$ 10.4 for Class II/1

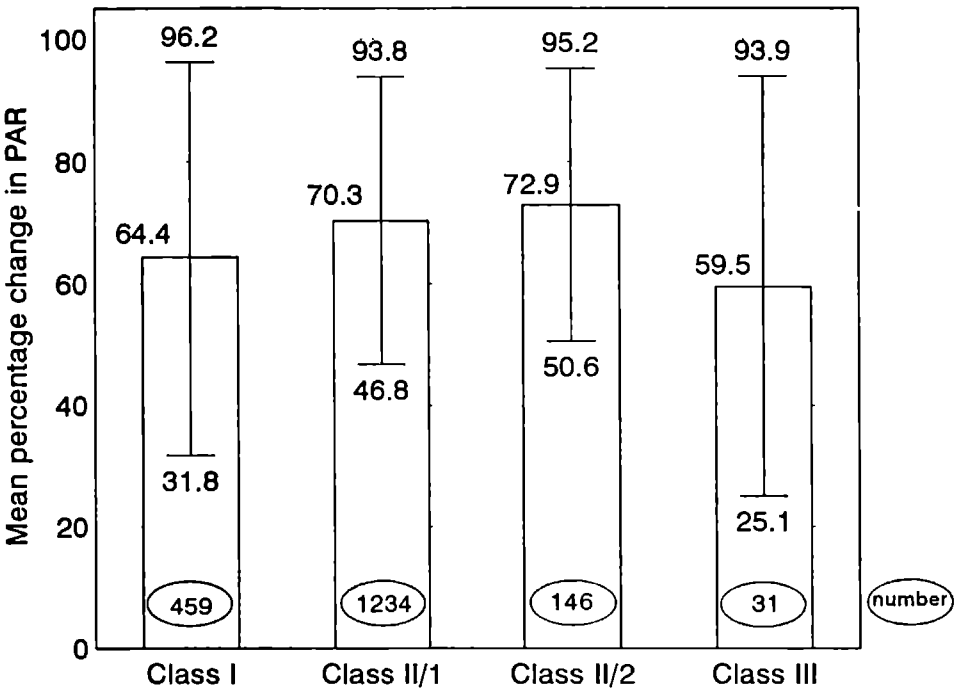

Figure 7-1: *Reduction in the PAR (mean percentual reduction and sd) for the Angle Classes at the post-treatment stage (T00).*

cases. The mean treatment duration indicates that Class I cases require less treatment time, but they have also the lowest PAR at the pretreatment stage. However, no correlation was found between the pretreatment PAR and the treatment duration.

The lowest mean PAR at the post-treatment stage was found for Class II/2 cases (6.2 $\pm$ 4.7) and it remained the lowest, compared to other Angle classes, until 5 years postretention. This may be due to the fact that most of the Class II/2 cases had a fixed retainer in the lower arch. In a previous study (Al Yami *et al.*, 1997) it was shown that cases with fixed retention had less change in the PAR at 5 years postretention than cases without fixed

Table 7-4: *Comparison of the mean PAR for the different Angle Classes at the pretreatment stage (TP), post-treatment stage (T00), postretention stage (T0), 2 years postretention (T2) and 5 years postretention (T5).*

		Angle Classification				
stage		I	II/1	II/2	III	P value
TP	mean	24.3	28.3	25.4	31.8	
	sd	10.9	9.5	9.4	12.4	< 0.001
	n	564	1583	180	41	
T00	mean	7.3	8.0	6.2	10.3	
	sd	6.0	6.2	4.7	8.0	< 0.001
	n	459	1234	146	31	
T0	mean	8.1	8.6	6.4	13.5	
	sd	7.1	6.3	5.1	9.6	< 0.001
	n	477	1371	143	37	
T2	mean	10.6	11.3	8.0	14.0	
	sd	8.7	7.6	5.8	9.4	< 0.001
	n	331	994	90	25	
T5	mean	12.4	13.0	10.3	17.4	
	sd	9.5	8.3	7.5	11.7	0.004
	n	277	801	66	23	

P value = one way ANOVA

retention. It should also taken into consideration that the PAR index does not measure incisor inclination. Improper treatment of Class II cases by retroclination of the upper incisors can not be detected by the PAR index.

Comparison of the mean percentage reduction in the PAR between the different malocclusion types shows that Class II cases have a higher mean percentage reduction when compared to other cases. This is mainly due to the high weight of the overjet, that is used in the PAR index. Although the Angle Class III cases start with the highest mean PAR, they show the lowest

percentage reduction. The weighting of the overjet will definitely influence the mean percentage change of the whole sample. Inclusion of a large number of Class II cases in the sample will exaggerate the overall treatment outcome when measured with the PAR. When used for self-evaluation purposes, the individual practitioner may manipulate the practice outcome by treating more Class II cases and by trying to avoid treatment of other malocclusions. So when comparing the results of different studies, the distribution of the Angle classes in the sample should be taken into consideration.

Table 7-5: *Comparison of the PAR mean change of the Angle classes with respect to the PAR at the adjacent treatment stage for all post-treatment stages.*

		Angle Classification				
period		I	II/1	II/2	III	P value
	mean	17.3	20.9	19.5	20.7	
TP-T00	sd	12.0	10.4	9.8	15.2	< 0.001
	n	459	1234	146	31	
	mean	0.4	0.5	0.04	1.3	
T00-T0	sd	5.5	4.6	5.0	7.9	0.435
	n	372	1022	109	27	
	mean	2.3	2.4	2.1	0.7	
T0-T2	sd	5.0	5.3	4.3	6.7	0.438
	n	304	937	86	24	
	mean	1.7	1.3	1.6	3.6	
T2-T5	sd	4.3	4.1	3.5	7.5	0.135
	n	216	643	45	17	

P value = One-Way ANOVA

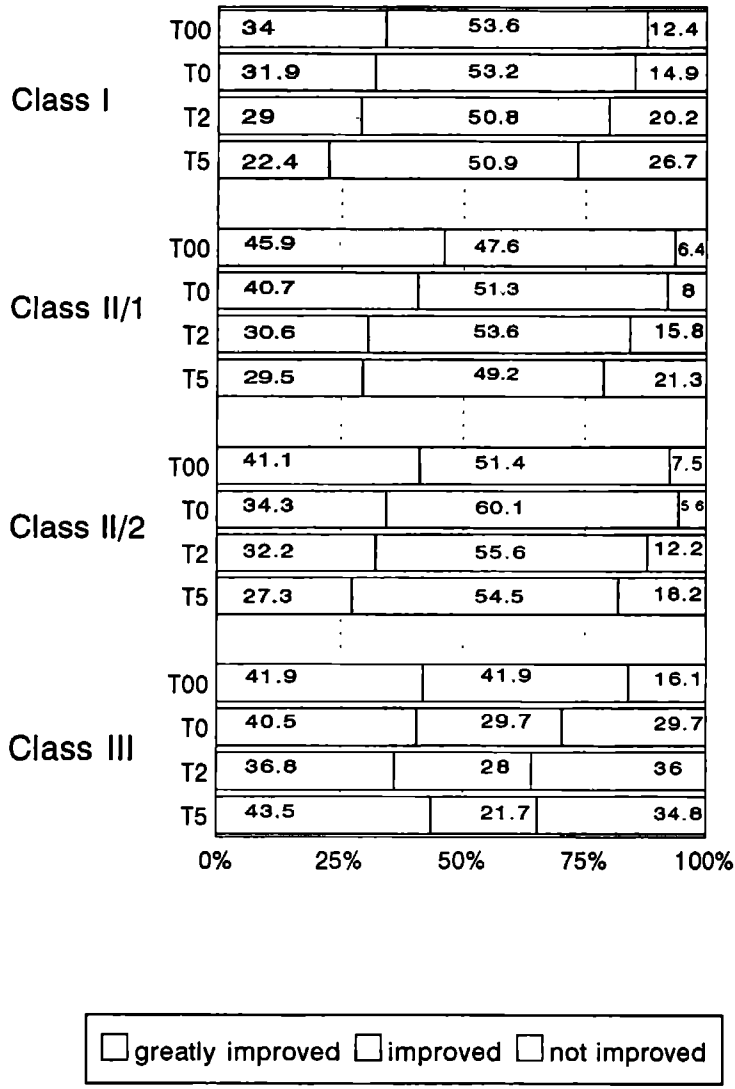

Figure 7-2: *Percentage of cases that are classified as 'greatly improved' (more than 22 points reduction in the PAR), 'improved' (more than 30% reduction) and 'not improved or getting worse' (less than 30% reduction) for the Angle Classes at post-treatment (T00), postretention (T0), 2 years postretention (T2), and at 5 years postretention (T5).*

It is clearly demonstrated in Figure 7-2 that Class I cases have the lowest percentage of cases in the "greatly improved" category. As these cases have a lower mean PAR at the pretreatment stage, it is difficult to achieve the 22 points reduction for the "greatly improved" category. This study also shows that Class III has the largest percentage of cases in the "not improved or getting worse" category, which indicates that the Class III malocclusion is the most difficult malocclusion to treat and to obtain 30% reduction in the PAR score. These results show that the description of the improvement according to the improvement categories is misleading. For example, a case which started with a PAR score of 21 and finished with a score of zero will be categorized as "improved", even if it was perfectly finished. The opposite is true for a case which started with a PAR score of 45 and finished with a score of 23. This is categorized as "greatly improved", while a definite malocclusion still exists.

7.6 Conclusion

In this study, the lowest PAR at the post-treatment stage was found for Class II/2 cases (6.2 $\pm$ 4.7), maintaining the lowest PAR until 5 years post-retention. Class III malocclusions have the highest PAR at the pretreatment stage and at all other post-treatment stages. There were no significant differences in the amount of relapse between different Classes as measured by the PAR index. When classifying the improvement into three categories, it was found that the treatment results tended to change over time from "greatly improved" to "not improved or getting worse". Inclusion of a large number of Class II cases in the sample will exaggerate the overall treatment outcome when measured with the PAR while the opposite is true for Class III. So, comparison of the results of different studies should take into consideration the distribution of Angle classes in the sample.

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Chapter 8

General discussion

8.1 Aim and rationale

The aims of this thesis were to assess the correlation between the Facial Attractiveness Scale (Peerlings *et al.*, 1995) and the Aesthetic Component of the IOTN index, to assess the biological changes in a non-orthodontic sample between 12 and 22 years of age using the PAR index (Richmond *et al.*, 1992a, 1992b, 1992c), and to perform a short-term and long-term analysis in a large sample of treated patients of both the treatment need, as measured with the IOTN (Brook and Shaw, 1989; Shaw *et al.*, 1995) and the treatment outcome, as measured with the PAR index.

The rationale for this study was that the IOTN and the PAR index are recently developed indices which have been accepted by many countries and researchers as objective methods to determine treatment need and to evaluate treatment outcome (Richmond and Andrews, 1993; Fox and Chadwick, 1994; O'Brien *et al.*, 1995; Otuyemi and Jones, 1995; Tang and So, 1995; Holmes and Willmot, 1996; Rinaldi *et al.*, 1996; Feghali *et al.*, 1997; Zody *et al.*, 1997). Also, the increased interest by orthodontists and health care providers, world wide, into the efficiency of orthodontic treatment induced us to this study (Shaw *et al.*, 1991b, 1995; Ter Heege, 1997).

8.2 Treatment need

The IOTN index was developed to distinguish patients with a higher treatment need from those with a lower treatment need and to give priority to the former (Shaw *et al.*, 1991a). In the past few years third party payment agencies and health administrators showed increased interest in the index too. However, the tendency exists to consider the Dental Health Component (DHC) only and to neglect the Aesthetic Component (AC). From the patients point of view facial and dental aesthetics are the main motivating factors to seek orthodontic treatment. The AC records the aesthetic impairment, and by implication, the justification for treatment on social-psychological grounds (Brook and Shaw, 1989). This means, when measuring treatment need

aesthetic need should be part of that, as was originally intended by the Manchester group. Our study has shown that only 5.8% (n = 54) of the patients has a treatment need based on aesthetic reasons only. So there is no risk for an extreme increase of treatment need as is feared by health insurance bodies when using the AC too.

In this study the question was raised whether dental aesthetics as measured by the IOTN is representative for facial aesthetics. No significant correlations were found in this study between facial and dental aesthetics which means that facial aesthetics and dental aesthetics are influenced by different factors. It can be assumed that evaluation of dental aesthetics while the lips are retracted is not representative for the dental appearance in normal day to day interaction. Therefore both dental and facial aesthetics should be evaluated when judging dento-facial aesthetics.

The rigid application of any index is inappropriate and not in the best interests of the patients. Just as it is inappropriate to orthodontically treat all patients in the IOTN-DHC grade 5 it may be equally inappropriate to reject all IOTN-DHC grade 3 cases. Patients might be excluded from orthodontic treatment because of the fact that they are classified as borderline need for treatment while an interceptive orthodontic treatment could prevent farther deterioration of the occlusal situation. This is especially the case for developing Class III malocclusions and developing deep bite cases. So, there is no suggestion that treatment should be withheld from IOTN-DHC grade 3 cases unless it is clearly against the patient's best interest (Holmes and Willmot, 1996).

Finally, it should be emphasized that the IOTN should not be used as a measure for treatment complexity; some patients with grade 5 could be treated relatively easy, while others, in grade 3, might well be technically more difficult and time consuming to treat. This also implies that the IOTN cannot be used to sort out general dental practitioner's and specialist's cases. The IOTN is, as the name suggests, a guide to treatment need. As such the IOTN is a clinical tool and the information it provides should be carefully interpreted in the doctor's office.

8.3 Treatment outcome

8.3.1 The PAR index

The PAR index was developed to measure the efficiency of orthodontic treatment in a rather simple, objective and reliable manner (Richmond *et al.*, 1993, 1995). This index, however, has some limitations. It only measures tooth position which, although important, is not the only factor in orthodontic treatment. Factors like incisor inclination, decalcification, root resorption, gingival recession, and functional and aesthetic considerations of the face are disregarded completely although they undoubtedly contribute to the quality of treatment.

Furthermore the description of the improvement according to the improvement categories is misleading. For example, a case which started with a PAR score of 21 and finished with a score of zero will be categorized as "improved" even if it was perfectly finished. The opposite is true for a case which started with a PAR score of 45 and finished with a score of 23. This is categorized as "greatly improved" even if a definite malocclusion still exists. So, the outcome of orthodontic treatment described with improvement categories should be carefully interpreted.

One of the features of the PAR index is that it is flexible in such a way that the weighting can be changed to reflect future standards and standards of other countries (DeGuzman *et al.*, 1995). The disadvantage, however, when doing so is that studies between different countries are no longer comparable. As no other Dutch studies were available, measuring treatment outcome with this index, we renounced from validation (weighting) of the PAR index according to Dutch orthodontic standards. In the future this validation is recommended to perform, incorporating all panels which provide orthodontic treatment i.e. orthodontists and general practitioners.

8.3.2 Short term outcome of orthodontic treatment

The outcome of orthodontic treatment is not purely the result of orthodontic mechanical interventions alone. In children physiological growth and development might also play a role in treatment outcome, either positive or

negative. As was shown in the untreated sample of this study (Chapter 3) no significant differences between the mean PAR score at 12 years and 22 years of age were found. These results confirm the conclusion of Afsharpanah *et al.* (1995, 1996) that, although the PAR scores for individuals change with normal growth and development, assessing orthodontic treatment outcome in a population sample does not require an untreated control sample for comparison.

The treatment outcome as measured with the PAR index in this study is comparable to other institutions which have comparable samples (O'Brien *et al.*, 1993). In this study the improvement in the PAR score at the post-treatment stages can be explained to some extent by the treatment period: more recent periods produced better quality. For an institution as well as for a private practice such an analysis can contribute to quality assurance of treatment outcome over the years. As such it is an important tool in the process of total quality management of orthodontic care provision.

In this study no attempt was made to compare treatment results produced by different types of appliances. It has shown that the use of two arch fixed appliances resulted in a significantly greater percentage reduction in the PAR than the use of removable or single arch fixed appliances. Single arch fixed appliances achieved a greater percentage reduction in PAR than removable appliances (O'Brien *et al.*, 1993; Shaw *et al.*, 1995). Future research on the same sample will be focused on this subject.

8.3.3 Stability of orthodontic treatment

Although improvement in the dentition can obviously be achieved, there is a tendency to return towards the original malocclusion many years post-treatment. In this study it is shown that the achieved results started to relapse even within the retention period. Classifying the improvement into three categories shows that the treatment results tended to change over time from "greatly improved" to "not improved or getting worse". This relapse pattern was comparable for all Angle Classes. Analyzing the relapse in the first ten years postretention, most of the relapse (19.2% per year) occurs in the first 2 years postretention. After this initial period of rapid relapse, the relapse

percentage during the next 8 years was substantially lower decreasing from 8.1% per year to 2.3% per year at 10 years postretention. Also, the changes in the PAR score were larger in the cases which finished the retention period at an earlier age. This might be explained by a remnant of growth which may influence the stability of the orthodontic treatment result. So, prolonging the retention period until the end of the active growth may diminish the fast deterioration of the treatment results.

The percentual change in the PAR at 5 years postretention was 51 per cent compared to a change of 69 per cent directly after active treatment, which seems to be disappointing. However, at the same time the percentage of patients with a definite orthodontic treatment need according to the IOTN was changing from 82% prior to treatment to 10% at 5 years postretention. This points to the assumption that the assessment of treatment need and treatment outcome are not based on the same set of criteria. A similar conclusion was reached in an international comparison of orthodontic professional assessments of treatment need and treatment outcome (Ter Heege, 1997). Development of an index that can be utilized for both purposes would be a step forwards.

A general question that should be raised regarding long-term results of orthodontic treatment is which length of period should give an appropriate estimate of stability. From the cost-effectiveness point of view a lifelong lasting effect of orthodontic therapy would be the preferred consequence. On the other hand Berg (1991) states that expecting a high degree of stability after 20 years exceeds the usual expectations in the other fields of medicine and dentistry. Other long term changes of the dentition due to growing, aging, periodontal diseases and caries, as well as various types of dental restorations should be considered. The present study shows that the changes that occur later than 10 years postretention are rather limited. Therefore it is suggested that an evaluation period of 10 years does justice to the nature of orthodontics.

8.4 Future research

Summarizing the suggestions in the previous paragraphs the following recommendations for future research are made:

1) Validation (weighting) of the IOTN and PAR indices is recommended to represent the Dutch orthodontic standard.
2) A study should be undertaken to develop an index that can be utilized to assess both treatment need and treatment outcome.
3) Since treatment outcome may rely on many factors such as appliances used, extraction or non-extraction treatment, adult treatment and many more, assessment of treatment outcome in respect to those treatment variables is recommended.
4) Related to the previous point, it has been documented in other countries that the quality of orthodontic treatment outcome differs between specialists and general practitioners, being better in the former. For the Netherlands such data is not available. So, assessment of the treatment outcome in patients treated by orthodontists and general practitioners is recommended.

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Chapter 9

Summary

This study was performed to evaluate orthodontic treatment need and treatment outcome in a large sample from the Department of Orthodontics and Oral Biology, University of Nijmegen.

Chapter 1 elucidates the background of the study and gives a review of the literature in the field of orthodontic treatment need and treatment outcome. The Index of Orthodontic Treatment Need (IOTN) and the Peer Assessment Rating (PAR) index which were utilized in this study were explained thoroughly.

Chapter 2 evaluates whether dental aesthetics as measured by the Aesthetic Component (AC) of the IOTN correlates with facial aesthetics. Facial attractiveness of 69 males and 75 females was scored on facial photographs at two different ages (11 to 13 years and 14 to 16 years). Scoring of the AC of the IOTN was undertaken on the dental casts. Increments between the observations at the two ages were calculated. To assess the association between scores of dental and facial aesthetics, correlation coefficients were calculated. There was a highly significant influence of orthodontic treatment on facial and dental aesthetic scores in the group which was not treated orthodontically at the first observation and was treated orthodontically at the second observation. No correlation, however, was found between the increments in the facial aesthetic score and the increments in dental aesthetic score. The results indicate that facial aesthetics and dental aesthetics are influenced by different factors. It was concluded that both dental and facial aesthetics should be evaluated when judging dento-facial aesthetics.

Chapter 3 assesses the effect of normal growth and development on the PAR index between 12 and 22 years of age. The sample consisted of 49 non-orthodontic subjects (24 male and 25 females) from the Nijmegen Growth Study. The mean age at the first observation was 12.2 $\pm$ 0.7 years and at the second observation 22.1 $\pm$ 0.6 years. The influence of the Angle classification and malocclusion severity on changes over time in the PAR score were evaluated. The mean changes in the PAR scores over time between cases which had more than 30% improvement to those which had less than 30% improvement were calculated. No significant differences

between the mean PAR score at 12 years of age (12.20 ± 0.91) and at 22 years of age (12.45 ± 1.28) were found, but there where relevant differences in individual cases. The changes were irrespective of the Angle classification or the malocclusion severity. Changes over time in the weighted PAR score were mainly correlated to changes in the anterior crossbite and the overjet. This correlation may be influenced, however, by the applied weighting factor for those occlusal traits.

Chapter 4 describes the evaluation of dental casts of 920 patients (400 male and 520 females) with the IOTN index at the pretreatment (TP) and 5 years postretention stages (T5). The mean age at TP was 12.2 ± 3.0 years and at T5 21.6 ± 3.1 years. At TP and T5 the Aesthetic Component (AC) and the Dental Health Component (DHC) were assessed. The difference between TP and T5 was compared for males and females and tested by the t-test. The changes in AC, DHC and treatment need categories were described at TP and at T5. Based on the combined AC and DHC treatment need categories 83% of the patients was falling in the "Definite need" prior to treatment and 10% of the patients was categorised as "Definite need" at 5 years postretention. No significant differences were found between males and females for the change in AC and DHC between TP and T5. The results indicated that the policy used in the department for patient selection is giving priority to the patients with a high treatment need. The results also provide a general impression of treatment outcome utilising the IOTN by analysing the change in the treatment need categories.

Chapter 5 evaluates the overall quality of orthodontic treatment. Standard orthodontic study models of 1870 patients (799 male and 1071 females) were evaluated at the pretreatment and post-treatment stage using the PAR index. The mean age at the pretreatment stage was 13 ± 4.1 years and at the post-treatment stage 16 ± 3.9 years. Mean and standard deviation (weighted) PAR score were calculated at the pretreatment stage and at the end of active treatment. The percentage reduction in the weighted PAR score was calculated to assess the improvement. The percentage of perfect scores (score = 0) of the different components of the PAR index was calculated. The analysis of variance was applied to compare the quality of treatment for

the variables treatment period and gender. The results show that the mean weighted PAR score was 27.6 ± 10, and 7.7 ± 6.1, for the pretreatment and post-treatment dental casts respectively. The mean percentage improvement was 68.9%. The mean treatment duration was 3.0 ± 1.4 years. 42.6% of the sample was greatly improved, 49.1% was improved and 8.3% was not improved or became worse. The improvement of the PAR score at the post-treatment stage was explainable to some extent by the treatment period: the more recent was the period the better was the quality.

In **Chapter 6** dental casts of 2368 patients were evaluated for the long term treatment outcome using the PAR index. The PAR index was applied at the pretreatment stage, directly post-treatment, postretention, 2 years post-retention, 5 years postretention and then every 5 years until 20 years post-retention. The mean absolute change as well as the percentual change per year (relapse) related to the postretention stage was calculated. ANOVA was applied to compare the mean change in the PAR between cases with and without a fixed retainer at the postretention stage and up to 10 years post-retention. The results indicate that 64% of the achieved orthodontic treatment result was maintained 20 years post-treatment. In the first two years after retention 19.2% per year of the orthodontic treatment relapse as measured with the PAR index takes place. Cases which finished the retention period earlier than 15 (female) or 16 (male) years of age showed more relapse. All occlusal traits relapsed gradually over time but remained stable at later stages with the exception of the lower anterior contact point displacement which showed a fast and continuous increase, even exceeding the initial score. It should be more commonly considered to maintain retainers if some growth is still expected. Also, all patients should be informed prior to treatment about treatment limitations in order to better meet their expectations.

In **Chapter 7** dental casts of 2368 patients were evaluated using the PAR index at pretreatment, post-treatment, postretention, 2 years postretention and 5 years postretention. One-way ANOVA was used to compare the treatment duration, the mean PAR, and the absolute and percentual change in the PAR for the different Angle Classes at all stages. The Scheffe test was used for multiple comparison. The lowest PAR at the post-treatment stage was found

for Class II/2 patients (6.2 $\pm$ 4.7), maintaining the lowest PAR until 5 years postretention. Class III malocclusions have the highest PAR at the pretreatment stage and at all other post-treatment stages. There were no significant differences in the amount of relapse between different Angle Classes at all post-treatment stages.

Chapter 8 discusses the results from the previous chapters and gives suggestions for future research.

Chapter 10

Samenvatting

Deze studie had als doel het onderzoeken van de orthodontische behandelbehoefte en de behandelingsresultaten van een grote groep patienten van de vakgroep Orthodontie en Orale Biologie van de Katholieke Universiteit Nijmegen.

Hoofdstuk 1 licht de achtergrond van het onderzoek toe en geeft een overzicht van de literatuur op het gebied van orthodontische behandelbehoefte en behandelingsresultaten. De 'Index of Orthodontic Treatment Need' (IOTN) en de 'Peer Assessment Rating' (PAR) index, die toegepast werden in dit onderzoek, worden uitvoerig beschreven.

In **Hoofdstuk 2** wordt onderzocht of de dentale esthetiek, gemeten met behulp van de Esthetische Component (AC) van de IOTN een correlatie vertoont met de esthetiek van het gelaat. De faciale esthetiek van 69 jongens en 75 meisjes werd gemeten aan de hand van foto's op twee verschillende leeftijden (11 tot 13 jaar en 14 tot 16 jaar). De meting van de AC van de IOTN werd gedaan op gebitsmodellen. De veranderingen tussen de twee observaties werden berekend. Om het verband vast te stellen tussen de metingen van de dentale en faciale esthetiek, werden correlatie-coëfficiënten berekend. De invloed van de orthodontische behandeling op de metingen van faciale en dentale esthetiek, was sterk significant voor de groep die niet orthodontisch behandeld was bij de eerste observatie en die orthodontisch behandeld was bij de volgende observatie. Er werd echter geen verband gevonden tussen de veranderde metingen van de faciale esthetiek en de veranderde metingen van de dentale esthetiek. Uit de resultaten blijkt dat de faciale esthetiek en de dentale esthetiek beïnvloed worden door verschillende factoren. Om die reden moeten zowel de dentale als de faciale esthetiek betrokken worden bij de beoordeling van de dento-faciale esthetiek.

Hoofdstuk 3 bespreekt het effect op de PAR index van de normale groei en ontwikkeling van 12 tot 22 jaar. De bestudeerde groep bestond uit 49 niet-orthodontisch behandelde individuen (24 jongens en 25 meisjes) uit het Nijmeegs Groeionderzoek. De gemiddelde leeftijd bij het eerste onderzoek was 12.2 $\pm$ 0.7 jaar en bij het tweede onderzoek 22.1 $\pm$ 0.6 jaar. De gebitsmodellen op deze leeftijden werden gemeten met behulp van de PAR index. De invloed van de Angle classificatie en de ernst van de malocclusie

op de veranderingen in de PAR werd onderzocht. De gemiddelde verandering in de PAR tussen de groepen die meer dan 30% verbetering en die minder dan 30% verbetering toonden, werd berekend. Uit de resultaten blijkt dat er geen significante verschillen waren tussen de gemiddelde PAR op 12 jarige leeftijd (12.20 ± 0.91) en op 22 jarige leeftijd (12.45 ± 1.28), maar wel waren er relevante verschillen binnen individuele patiënten. De veranderingen waren onafhankelijk van de Angle classificatie of de ernst van malocclusie. Veranderingen in de 'weighted PAR' waren voornamelijk gecorreleerd aan de veranderingen in het front en de sagittale overbeet. Deze correlatie kan echter door de toegepaste 'weighting factor' voor deze occlusale kenmerken beïnvloed zijn.

Hoofdstuk 4 beschrijft de evaluatie van gebitsmodellen van 920 patiënten (400 jongens en 520 meisjes) aan de hand van de IOTN index voorafgaand aan behandeling (TP) en 5 jaar na retentie (T5). De gemiddelde leeftijd bij TP was 12.2 ± 3.0 jaar en bij T5 21.6 ± 3.1 jaar. Bij TP en T5 werd de Esthetische Component (AC) en de Dentale Health Component (DHC) bepaald. Het verschil tussen TP en T5 werd vergeleken voor jongens en meisjes en door middel van de t-test getoetst. De veranderingen voor AC, DHC en de behandelbehoefte-categorieën werden verklaard voor TP en voor T5. Voor behandeling viel 83% van de patiënten in de categorie "definitief" een behandeling nodig. Dit was gebaseerd op de gecombineerde AC en DHC behandelbehoefte-categorie. Vijf jaar na retentie werd 10% van de patiënten geclassificeerd als "definitief een behandeling nodig".

Er werden geen significante verschillen gevonden tussen jongens en meisjes ten aanzien van de veranderingen in AC en DHC tussen TP en T5.

Uit de resultaten blijkt dat de toegepaste strategie met betrekking tot patiënten selectie voor orthodontische behandeling, prioriteit verleent aan patiënten met een hoge behandelbehoefte.

Hoofdstuk 5 onderzoekt de kwaliteit van orthodontische behandelingen in het algemeen. Gestandaardiseerde orthodontische studiemodellen van 1870 patiënten (799 jongens en 1071 meisjes) werden onderzocht vóór en na orthodontische behandeling met behulp van de PAR index. De gemiddelde leeftijd vóór de behandeling was 13 ± 4.1 jaar en na de behandeling

16 ± 3.9 jaar. De gemiddelde (weighted) PAR score werd berekend vóór en na de actieve behandeling. De percentuele reductie in de weighted PAR score werd berekend om de verbetering vast te stellen. Het percentage perfecte scores (score = 0) van de verschillende componenten van de PAR index werd berekend. De variantie-analyse werd toegepast ter vergelijking van de kwaliteit van de behandeling voor de verschillende chronologische behandelingsperioden en het geslacht. Uit de resultaten blijkt dat de gemiddelde weighted PAR score vóór behandeling 27.6 ± 10 bedroeg en na behandeling 7.7 ± 6.1. De gemiddelde verbetering was 68,9%. De gemiddelde behandeltijd was 3.0 ± 1.4 jaar. 42,6% van de geselecteerde groep was sterk verbeterd, 49,1% was verbeterd en 8,3% was niet verbeterd of zelfs slechter geworden. De verbetering van de PAR direct na afbehandeling kon ten dele verklaard worden uit de behandelperiode: hoe recenter de periode hoe beter de kwaliteit.

In **Hoofdstuk 6** werden de gebitsmodellen van 2368 patiënten onderzocht over een lange periode na afbehandeling met behulp van de PAR index. De PAR index werd gemeten vóór de behandeling, direct na afbehandeling, na de retentiefase, 2 jaar na de retentiefase, 5 jaar na de retentiefase en vervolgens elke 5 jaar tot 20 jaar postretentie. De gemiddelde absolute verandering en ook de percentuele verandering per jaar (relapse) gerelateerd aan de retentiefase werden berekend. ANOVA werd toegepast voor het vergelijken van de gemiddelde verandering in de PAR tussen gevallen met en zonder permanente retentie gedurende een retentiefase tot 10 jaar. Uit de resultaten blijkt dat 64% van het verkregen orthodontische behandelingsresultaat 20 jaar na afbehandeling behouden bleef. Gedurende de eerste twee jaren na retentie vond 19,2% orthodontische 'relapse' per jaar plaats, gemeten met de PAR. Gevallen waarbij de retentiefase eerder dan op 15-jarige leeftijd (meisjes) of op 16-jarige leeftijd (jongens) was beëindigd, vertoonden meer 'relapse'. Alle occlusale deelscores van de PAR toonden geleidelijk aan een 'relapse', maar bleven stabiel in een latere fase met uitzondering van het onderfront, dat een snelle en continue toename van de PAR deelscore vertoonde, en zelfs de beginscore overschreed. Het dient derhalve aanbeveling de retentieapparatuur te handhaven indien nog groei te

verwachten is. Eveneens verdient het aanbeveling patiënten voorafgaand aan de behandeling te informeren over de te verwachten behandelresultaten en het te verwachten resultaat op lange termijn, teneinde zo beter aan hun verwachtingen te voldoen.

In **Hoofdstuk 7** wordt onderzoek beschreven aan gebitsmodellen van 2368 patiënten, die gescoord werden met behulp van de PAR index vóór de behandeling, aan het eind van de aktieve behandeling, na retentie, 2 jaar postretentie en 5 jaar postretentie. One-way ANOVA en de Scheffe test werden gebruikt voor het vergelijken van de behandeltijd, de gemiddelde PAR en de absolute and percentuele veranderingen in de PAR voor de verschillende klassen volgens Angle voor iedere fase. De laagste PAR score aan het einde van de aktieve behandeling werd gevonden voor Klasse II/2 patiënten (6.2 ± 4.7), die de laagste PAR behielden tot 5 jaar postretentie. Klasse III afwijkingen hadden de hoogste PAR score vóór behandeling en tevens in alle fasen na afbehandeling. Er waren geen significante verschillen in de mate van 'relapse' tussen de verschillende Angle Classificaties.

In **Hoofdstuk 8** worden de resultaten van de voorafgaande hoofdstukken bediscussieerd en enkele suggesties gegeven voor nader onderzoek.

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Curriculum vitae

The author Essam Ahmed Al Yami was born on May 27, 1964, in Makka, Saudi Arabia. He is married to Hayat Al Wadie and they have three children: Abdulrahman (1988), Adba (1991), and Shahd (1997).

He went to Thakief secondary school (science section), from 1979 to 1982. Then he studied dentistry at King Saud University (Saudi Arabia) from 1982 to 1988. He fulfilled his internship Program (Dental college, King Saud University), from 1988 to 1989.

He practised general dentistry at Assir Dental Centre (Ministry of Health) from 1989 to 1993 where he acted as director of the Centre from 1990 to 1993. He has been active member of the Medico-Legal Committee, as well as active member of the Research Committee (Assir Region) from 1991 to 1993. He posted also as a director of Assir Central Hospital from 1992 to 1993. In 1993 he enrolled in the orthodontic postgraduate training program at the University of Nijmegen (the Netherlands), from 1993 to 1997, where he finished this program August 16, 1997.

Summary in Arabic

جميع السمات التطابقية للأسنان تتعرض لنسبة مطردة من الانتكاسة عبر الزمن وتستقر الحالات في مرحلة متقدمة . باستثناء انحراف تراصّ الأسنان الأمامية بالفك السفلي التي تظهر إنتكاسة سريعة ومستمرة حتى أن هذه الانتكاسة تتجاوز الوضع لمرحلة ما قبل العلاج.
يوصى بتمديد مرحلة الاستبقاء ما دام هنالك نمو متوقع . وكذلك إشعار المريض قبل العلاج عن حدود وإمكانية العلاج حتى تتوافق النتيجة العلاجية بشكل أفضل مع توقعاته .

الجزء السابع :

تم تقييم المجسم السني لـ ٢٣٦٨ مريضا مستخدمين مقياس الـ PAR في مراحل ما قبل العلاج وما بعد العلاج وما بعد مرحلة الاستبقاء ، وبعد سنتين من نهاية مرحلة الاستبقاء وبعد خمس سنوات من نهاية مرحلة الاستبقاء .
تم مقارنة المدة العلاجية ومتوسط درجة الـ PAR والتغير المطلق والنسبي لجميع أنواع التشوه السني حسب تصنيف Angle لجميع المراحل السابقة الذكر .
أشارت النتيجة الى أن أقل درجة PAR في مرحلة ما بعد العلاج كانت للتشوه السني المصنف II/ 2 (٦,٢ درجة) وتم احتفاظه بأقل درجة حتى المرحلة ٥ سنوات ما بعد مرحلة الاستبقاء . أما التشوه السني المصنف III فقد إختص بأعلى درجات PAR في جميع المراحل العلاجية .
ليس هناك إختلاف جوهري ما بين التشوهات السنية المختلفة حسب تصنيف Angle من حيث الانتكاسة في النتيجة العلاجية .

الجزء الثامن :

تمت المناقشة بصورة شاملة لجميع النتائج من الأجزاء السابقة . وتم إعطاء بعض الإرشادات للبحوث المستقبلية .

الجزء الخامس :

تم تقييم الجودة النوعية لعلاج تقويم الأسنان في قسم تقويم الأسنان بجامعة نيميخن بصورة شاملة من خلال المجسم السني لـ ١٨٧٠ مريضا (٧٩٩ ذكرا و ١٠٧١ أنثى) في المرحلة ما قبل وبعد العلاج مستخدمين مقياس الـ PAR. المتوسط العمري للعينة ١٣ سنة في المرحلة ما قبل العلاج و ١٦ سنة في المرحلة ما بعد العلاج .

تم حساب المتوسط لدرجة الـ PAR لمرحلة ما قبل وما بعد العلاج وكذلك تم حساب النسبة المئوية للتغير لتحديد درجة التحسن . تم حساب النسبة المئوية الحاصلة على الدرجة صفر (الدرجة المثالية) لجميع عناصر مقياس الـ PAR . كما تم مقارنة الجودة النوعية للعلاج للمتغيرات (الفترة الزمنية والجنس) .

أشارت النتيجة الى أن متوسط درجة الـ PAR هي ٢٧.٦ في المرحلة ما قبل العلاج و ٧.٧ درجة في مرحلة ما بعد العلاج . وكانت النسبة المئوية للتغير ٦٨.٩ ٪ . كان متوسط المدة العلاجية ٣ سنوات .

٤٢.٦ ٪ من العينة تحسنوا بدرجة عالية ، ٤٩.١ ٪ تحسنوا بدرجة متوسطة و ٨.٣ ٪ لم تتحسن أو لم تتغير الحالة .

التحسن في درجة الـ PAR في مرحلة ما بعد العلاج يمكن تفسيره الى حد ما بالفترة الزمنية للعلاج (تتحسن الجودة النوعية للعلاج مع حداثة الفترة العلاجية) .

الجزء السادس :

تم تقييم المجسمات السنّية لـ ٢٣٦٨ مريضا باستخدام مقياس الـ PAR. تم التقييم لجميع المراحل العلاجية المتوفرة (ما قبل العلاج، ما بعد العلاج ، ما بعد مرحلة الاستبقاء مباشرة، بعد سنتين من نهاية مرحلة الاستبقاء ، بعد خمس سنوات من نهاية مرحلة الاستبقاء ، ثم بعد كل خمس سنوات حتى ٢٠ سنة ما بعد مرحلة الاستبقاء) .

تم حساب المتوسط المطلق والمئوي للتغير السنوي في درجة الـ PAR لما بعد مرحلة الاستبقاء الذي يعكس درجة الانتكاسة في النتيجة العلاجية . كما تم مقارنة درجة الـ PAR للحالات التي تم والتي لم يتم استخدام طريقة التثبيت الدائم بها حتى ١٠ سنوات ما بعد العلاج .

تشير النتيجة الى أنه في السنتين الأولى والثانية ما بعد مرحلة الاستبقاء يحدث ما نسبته ١٩.٢ ٪ من الانتكاسة العلاجية ، وأن الحالات التي أنهت فترة الاستبقاء ما قبل العمر ١٥ سنة للإناث و١٦ سنة للذكور تتعرض الى انتكاسة أكبر .

تم التقييم حسب تصنيف Angle وشدة التشوه السني على التغير في درجة الـ PAR ما بين الملاحظتين . كذلك تم حساب متوسط التغير في درجة الـ PAR مع مرور الوقت للحالات التي تحسّنت بنسبة أقل أو أكثر من ٣٠٪ .

أثبتت النتائج عدم وجود علاقة ذات أهمية إحصائية ما بين درجة الـ PAR في العمر ١٢ سنة (١٢.٢٠) و العمر ٢٢ سنة (١٢.٤٥) ولكن هنالك حالات إستثنائية أظهرت وجود اختلاف جوهري في درجة الـ PAR في الملاحظة الأولى عنه في الملاحظة الثانية. ليس هناك علاقة بين التغير في درجة الـ PAR وتصنيف Angle والتغير وشدة التشوّه السنّي .

التغير من خلال الوقت لدرجة الـ PAR المثقلة كان ذا علاقة أكبر مع البروز السني الإيجابي والسلبي ، هذه العلاقة قد تكون متأثرة بمعامل التثقيل لهذين النوعين من التشوّه في علاقة الأسنان .

الجزء الرابع :

تم تقييم الحاجة العلاجية لـ ٩٦٠ مريضا (٤٠٠ من الذكور و٥٦٠ من الإناث) باستخدام مقياس (IOTN) وذلك في مرحلة ما قبل العلاج وكذلك بعد ٥ سنوات من انتهاء علاج تقويم الأسنان . كان متوسط العمر في المرحلة الأولى ١٢.٢ سنة وفي المرحلة الثانية ٢١.٦ سنة .

تم رصد الحاجة العلاجية من خلال عنصر الصحة السنية (DHC) وعنصرالجمال (AC) لمقياس الـ (IOTN) . تم مقارنة الفرق ما بين المرحلة الأولى والثانية للذكور والإناث كلا على حدة . كذلك تم وصف التغير من خلال عنصري الصحة السنية والجمال السني وكذلك من خلال تصنيف الحاجة العلاجية مع مرور الوقت .

بناءً على معيار الحاجة العلاجية بأخذ أعلى المؤشرات للحاجة العلاجية سواء كانت من الناحية الصحية أو الجمالية فإن ٨٣ ٪ من المرضى في حاجة علاجية ماسة لتقويم الأسنان في مرحلة ما قبل العلاج . وكانت النسبة المئوية ١٠ ٪ من المرضى في حاجة ماسة للعلاج بعد مرور خمس سنوات على العلاج .

ليس هناك اختلاف ذو أهمية إحصائية ما بين الذكور والإناث للتغير في عنصري مقياس الـ (IOTN) .

النتيجة تشير الى أن السياسة في عملية إنتقاء المرضى في قسم تقويم الأسنان تعطي أولوية للمرضى الذين هم بحاجة ماسة للعلاج . كما أن النتيجة تعطي إنطباعا عاما عن النتيجة العلاجية من خلال تحليل التغير في تصنيف الحاجة العلاجية لمقياس الـ (IOTN).

ملخص

الهدف من هذه الدراسة هو تقييم الحاجة العلاجية والنتيجة العلاجية لعلاج تقويم الأسنان في عيّنة كبيرة من المرضى من قسم تقويم الأسنان بجامعة نيميخن .

الجزء الأول :

يوضح الخلفية من وراء البحث وكذلك استعراض البحوث العلمية في مجال الحاجة العلاجية والجودة العلاجية لعلاج تقويم الأسنان .
تمّ الشرح بصورة مفصلة لمقياس الحاجة العلاجية لعلاج تقويم الأسنان (IOTN) وكذلك لمقياس الجودة النوعية لعلاج تقويم الأسنان PAR- Index .

الجزء الثاني :

تمّ تقييم العلاقة بين الجمال السنّي والجمال الوجهي من خلال تقييم الجاذبية المنبعثة من الوجه لـ ٦٩ من الذكور و ٧٥ من الإناث باستعراض صور فوتغرافية للوجه في فترتين مختلفتين من العمر (ما بين ١١ سنة و١٣ سنة - وما بين ١٤ سنة و ١٦ سنة) .
تمّ تقييم الجمال السنّي من خلال المجسم السنّي وتم حساب التغير في الفترة ما بين العمرين . كذلك تمّ اختبار العلاقة ما بين الجمال السنّي والجمال الوجهي .
أظهرت النتائج وجود تأثير ذو أهمية عالية لعلاج تقويم الأسنان في الجمال السنّي والوجهي . وأنه ليس هنالك علاقة مباشرة ما بين التحسّن في الجمال الوجهي والتحسن في الجمال السنّي. النتيجة تقودنا الى أن الجمال السنّي والجمال الوجهي يتأثران بعوامل مختلفة .

الجزء الثالث :

تمّ تقييم تأثير النمو الطبيعي ما بين العمر ١٦ سنة و ٢٢ سنة على مقياس الـ PAR العيّنة تكونت من ٤٩ شخصا (٢٤ ذكرا و٢٥ أنثى) استخلصت من دراسة نيميخن للنمو حيث لم يتم علاج التشوهات الفكية والسنية لديهم . متوسط العمر ١٢.٢ سنة خلال الملاحظة الأولى و ٢٢.١ سنة خلال الملاحظة الثانية .

ملخص البحث

الحمد لله
أوله وآخره
ظاهره وباطنه

إهداء

الى :

الوالدة الحبيبة

الزوجة الغالية

الأطفال الأعزاء

تقويم الأسنان :

الحاجة العلاجية والنتيجة العلاجية

بحث علمي في مجال العلوم الطبية

أطروحة

مقدمة كأحد المتطلبات للحصول
على درجة الدكتوراه في العلوم الطبية
من جامعة نيميخن
حسب قرار مجلس العمداء
بمشيئة الله سوف تتم المناقشة بحضور الجمهور
في يوم الثلاثاء الموافق ٢٣ سبتمبر ١٩٩٧
في تمام الساعة ١١ صباحا

من قبل

عصام بن أحمد اليامي

المولود ١٩٦٤/٥/٢٧م
بمكة المكرّمة

١٩٧٧

تم الطبع بهولندا بواسطة : مطابع بندا (نيميخن)

تقويم الاسنان :

الحاجة العلاجية

و

النتيجة العلاجية

عصام بن أحمد اليامي